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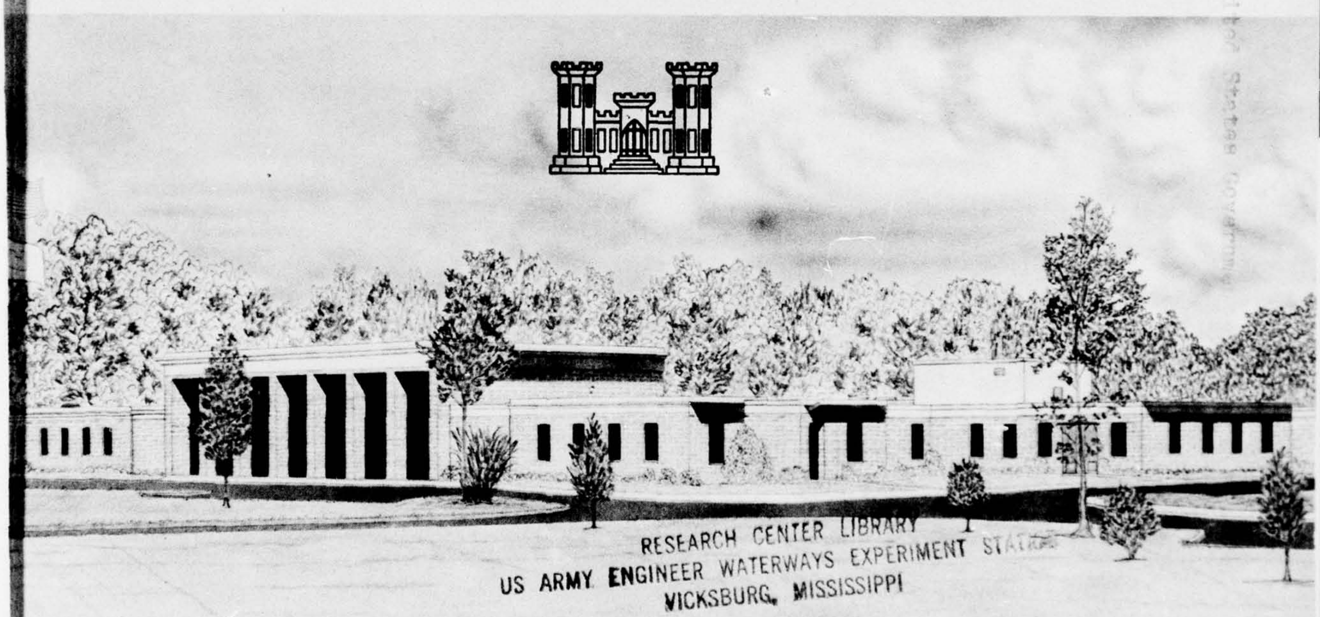
by

LTC Frederick M. Anklam



June 1971

Sponsored by Office, Chief of Engineers, U. S. Army

Conducted by U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

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ARMY-MRC VICKSBURG, MISS

FOREWORD

This study was conducted for the Office, Chief of Engineers, Civil Works Task Group for Inland Waterways Systems Analysis per letter ENGCW-PE, dated 8 September 1970, from BG R. H. Groves, Project Manager. In the approach to contemporary large-scale problems it is desirable that alternatives be developed prior to a major decision being made. This report concerns the alternative of improving current operation of the components of the inland waterways system and the system as a whole rather than solving problems only with new construction. The study was based upon distribution of a questionnaire, Task Group meetings and discussions, and visits to Corps of Engineers Civil Works offices and river sites by the author, LTC Frederick M. Anklam, CE, Deputy Director of the U. S. Army Engineer Waterways Experiment Station (WES).

Dr. John Harrison of the Mathematical Hydraulics Branch of the WES Hydraulics Division was most helpful throughout the study, performing this service in addition to his own duties for the Task Group in the area of mathematical modeling and methodologies. The queueing theory diagrams on pages N-A-4 and N-A-5 and table N-A-2 are his work. The assistance in the compilation of Appendix B by PVT Gary Wintergerst, a civil engineer assigned to WES under the Army's Scientific and Engineering Assistants Program, is particularly appreciated. Miss Marie Spivey of the WES Research Center Library very efficiently collected, abstracted, and prepared the selected bibliography which permitted a rapid response in this report. Extensive editing and review were performed by Dr. Harrison and PVT Wintergerst of the Mathematical Hydraulics Branch, and Mr. Richard T. Smart of the Reproduction and Reports Office, WES. In addition, the personal review in detail of COL Ernest D. Peixotto, CE, the Director, and Mr. Frederick R. Brown, the Technical Director, was of great benefit in improving the end product.

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SUMMARY

The inland waterways system of the United States as it exists today has a number of problems associated with near-capacity traffic conditions. In many places on the Mississippi, Ohio, and Missouri Rivers and their navigable tributaries, there are serious impediments to the free flow of waterborne commerce. This study was conducted to determine the potential for more efficient utilization of existing inland waterways resources and facilities as a possible alternative to heavy investment in major construction. The study was based on distribution of a questionnaire, meetings and discussions with the Civil Works Task Group for Inland Waterways Systems Analysis, and visits to Corps of Engineers Civil Works offices and river sites by the author.

The inland waterways system is an intimate interweaving of three significant subsystems: the physical waterway, the towing industry, and the commodities. These subsystems and their interrelations are discussed in detail herein. It was determined that there are a number of areas of potential for improvement in the inland waterways system. These areas involve such items as changes in operating procedures of the locks, revisions of the operating rules for towboats approaching and using locks, staffing considerations, additional assistance at heavily trafficked locks, and other such factors. The following two examples illustrate possible improvements. The study of the Welland Canal in the Canadian portion of the St. Lawrence Seaway was a most productive effort. Through improved management of both the lock system and the shipping in the canal, major investments were delayed while significant increases in ship passage were realized. Also, at the industrial canal in New Orleans, Louisiana, and in recent tests at Lock and Dam 26 on the Mississippi River near St. Louis, Missouri, the use of extra towboats to assist long tows through the locks was very productive. In the Lock and Dam 26 tests, an estimated $100,000 in time-saving benefits was realized by the towing industry for a $26,000 cost.

It is concluded that there is considerable evidence that significantly more traffic can be passed through our inland waterways system through the medium of nonstructural or low cost modifications in operating rules, lock operations, and facilities. This will enable the Civil Works Directorate to apply capital improvement investment more effectively at the places where it is the only solution while materially increasing our capability to pass increased traffic at other locations for considerable periods of time.

It is recommended that the Office, Chief of Engineers, actively pursue the concept of nonstructural or low cost improvements in lieu of major construction prior to major investments at any given location. The effect of any improvements should be evaluated with regard to that location and also with regard to other locations under the systems concept.

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POTENTIAL NONSTRUCTURAL OR LOW COST WATERWAYS SYSTEM IMPROVEMENTS

I. STATEMENT OF THE PROBLEM

The inland waterways system as it exists today has a number of problems associated with near-capacity traffic conditions. In many places on the Mississippi, Ohio, and Missouri Rivers and their navigable tributaries, there are serious impediments to the free flow of waterborne commerce. This study pertains to the potential for more efficient utilization of existing inland waterways resources and facilities.

II. ASSUMPTIONS

A. Federal funds will not be available to meet all inland waterways construction needs simultaneously. Priorities must be established to provide the greatest return for the investment dollar in the overall system.

B. There will be a continuing increase in the growth of waterborne commerce for the foreseeable future. The following is a summary of experienced and projected traffic on the entire Ohio River as reported by Kent in the July 1969 ASCE Transportation meeting:

	1960	1980	2000	2020
Millions of tons	79.5	182	329	531
Billions of ton-miles	17.7	42	76	127

C. In the near future there will not be a major shift of transportation modes which would reduce the quantities of high volume/low cost materials traditionally moved on the inland waterways system.

D. There will be no significant change in the types of equipment used by the towing industry.

E. Locks will continue to provide the change of level for waterborne commerce at dams.

III. FACTS BEARING ON THE PROBLEM

A. At specific points the major inland waterways system is now saturated with traffic. Examples of this are Lock and Dam 26 at St. Louis on the Mississippi River and Locks and Dams 52 and 53 on the Ohio River. It was recently deemed necessary to consider construction of an additional temporary lock at Lock and Dam 53 to pass traffic until major construction could be carried out. At these and other locations there are queues of river traffic frequently waiting three or more hours to pass through a lock. Such waiting times impose large financial penalties on the users of the inland waterways system and ultimately upon the consuming public.

Conversely, benefits to the consuming public and the towing industry will accrue through greater traffic capacity.

B. Recent interest from the Office of the Secretary of the Army has required that the Chief of Engineers use the systems approach in developing and justifying major improvements or new construction.

C. There are approximately 6339 miles of existing and projected waterway and 139 locks between the Appalachians and the Rockies and from Canada to the Gulf Coast, exclusive of the Great Lakes and the Gulf Intracoastal Waterways.

D. A St. Louis District test at Lock and Dam 26 resulted in an estimated $100,000 benefit to the industry while passing the largest monthly tonnage of record. The total cost was $26,000 with no construction or alterations effected.

IV. DISCUSSION

A. General. The inland waterways system is an intimate interweaving of three significant subsystems: the physical waterway, the towing industry, and the commodities.

1. The physical waterway is the river and canal system upon which waterborne commerce navigates. It consists of natural and improved sections with dams and locks throughout major portions of the system. Waterway capacity for traffic is a function of the river cross section; the restrictive points such as locks, sharp bends, and bridge piers; the main channel alignment; the tow configurations; and the traffic density.

2. The towing industry is made up of modular units which are either used in general bulk cargo hauling of such items as coal, grain, sand, and gravel, or of equipment which essentially has one use, such as tank barges for petroleum products, steam heated barges for sulphur transport, and large barges for movement of moon rocket components. There is a wide variety of towboat equipment and barge sizes. The industry's general tendency at the present time is toward larger towboats and longer tows, currently 1200 ft long and longer. In many cases equipment is designed to fit exactly into locks.

3. The third subsystem consists of commodities which originate at various input locations known as river ports and are delivered to other river ports, their destination, or output locations. Some of these commodities are produced on the banks of the system itself; coal from Tennessee and West Virginia is an example. Other commodities are transported relatively long distances before they are transferred to waterborne commerce; grain from the mid-Continental United States for example. There is no cheaper way to move many bulk materials than by pushing them in a barge with a modern diesel towboat. The following examples of comparative freight rates were provided recently by Mr. Richard Waugh of the Board of Engineers for Rivers and Harbors:

COAL:	Ohio River (370 river miles): 3.5 to 4 mils/ton-mile
	Rail, unit train (212 RR miles): 5 to 7 mils/ton-mile
GRAIN:	Minneapolis to New Orleans (1700 miles)
	Water: 2 to 3 mils/ton-mile
	Rail (unit train): 7 to 8 mils/ton-mile
	Joliet to New Orleans (1200 miles)
	Water: 2.3 mils/ton-mile
	Rail (unit train): 4.8 mils/ton-mile

B. Systems Analysis. In the sense of this report, systems analysis means the understanding and quantification of the interrelations between various elements of any system as well as the broad spectrum approach to all parts of the problem. Insights must be gained as to the effect of a change in one portion of the system on all other parts of the system and in particular the changes at several locations as they interact. Traditional methods must be reevaluated and modern technology must be applied to all parts of the problem, the people as well as the things.

C. Waiting Lines. The towing industry is now subjected to serious delays at several points on the waterway system, and more severe problems are anticipated in the not too distant future. Waiting lines are an irritating fact of life frequently imposed at auto toll booths, detours, supermarket checkout counters, public phone booths, and many other locations where service is desired. Queuing theories developed from the fields of statistics and operations research have given some insight into the nature of the waiting problem. As arrival times (time between successive appearances of the next customers) approach service times (e.g. time required to be checked out at the supermarket), waiting lines build up with consequent delays and opportunities lost by the customer in the waiting line.

The standard method of studying these problems is through steady state approximations of these usually dynamic situations. Where there is a waiting line and a continuing supply of customers arriving, steady state approximations are often valid. Detailed studies and subsequent changes in service operations have often resulted in a significant reduction in both the waiting time and the length of the waiting line as a result of only a small decrease in service time. These rather small service time reductions often are magnified into significant improvements as far as the waiting customers are concerned. A simplistic example of these principles is presented in figs. N-A-2 and N-A-3 on pages N-A-4 and N-A-5. As can be seen in fig. N-A-2, for an arrival rate of 17 tows per day, a service time (i.e. time required to pass a tow through the lock) of 64 minutes results in an average waiting time of approximately 200 minutes. A decrease in service time of approximately 10 percent, to 58 minutes, reduces the average waiting time to 126 minutes, an average saving of 74 minutes for each tow in the waiting line. This is a 37 percent reduction in delay for each tow. Further examples are shown in table N-A-2 on page N-A-3. A sixty-four percent reduction in waiting time for each tow could be realized for a 22 percent reduction in service time under the given example conditions.

The information presented here is, as mentioned above, a simplistic example given to demonstrate the potential savings available through relatively small reductions in service time. At a rate of $80.00 per operating hour for a 3000-horsepower tow with nine barges, significant savings can be realized at busy locations. Such savings, of course, are conservative in that they do not reflect the improvements in scheduling, delivery times, and capability for more round trips which ultimately benefit the consumer.

The intensive study of such factors and the interaction between closely related lock locations in the Welland Canal and the Panama Canal have also led to very significant savings and capacity improvements. As a result of these type studies, the Welland Canal was able to pass sharply increased traffic in the period 1965-1968 while major new construction of locks was in progress. In an extreme case, savings of 1500 minutes or $3,000,000 could accrue to the shipping industry using the Welland Canal if modified rules were applied.

D. Potential Waterway Improvements. A traditional approach has been to meet a heavy traffic problem with new construction. However, as new construction is completed, there is often a transfer of the traffic problem from one location on the system to another. This then creates a new pressure point in the waterborne commerce bloodstream and a new requirement for more construction. If this traditional construction-oriented approach is followed, the growth of both industry and commerce is such that very expensive facilities construction is unavoidable. The new Lock and Dam 26, for instance, at St.Louis will cost about $245,000,000. Many other projects of this magnitude will be required throughout the system if only new construction is considered as a solution. Each year that a project such as Lock and Dam 26 could be delayed would lead to a saving of $16,500,000, or an opportunity to apply that amount to a place where immediate construction has been found by systems analysis techniques to be the optimum solution.

There is considerable evidence that either nonstructural or low cost system improvements may lead to significantly increased capability to pass more tonnage within the existing system. An example of this is the improvement in passing more tonnage through locks at some locations by improving hydraulic operation of the lock itself. In other cases, increased staffing at a lock can lead to faster cycles and a resultant increase in the tonnage passed.

Of considerable significance is a recent test conducted by the St. Louis District at Lock and Dam 26. When long tows appear at the lock, the traditional practice has been to split the tow into two or three parts, pass each part through the lock, and then reassemble the tow in the immediate lock area. Significant reductions in delays have been accomplished by having a locally available extra towboat assist a long tow as it is broken up and reassembled. The towboat operates somewhat like a switch engine in a railroad yard. The cost of the St. Louis District test of this method of operation was approximately $26,000 over a one-month period; $100,000 worth of benefits to the towing industry and the commodity system

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were realized by eliminating several hours of delay for 835 tows. In essence, the reduction of a double-lockage tow time from an average of 90 minutes to 60 minutes for its two independently powered parts resulted in the largest passage of tonnage ever for a similar period.

Another example of a nonstructural improvement has been the establishment of an operating rule such that when waiting lines of towboats form from both directions, the lock is operated in one-way traffic for a given number of tows and then the other direction for a given number of tows. Though this appears to be wasteful since the lock must be filled without a tow in it (the downstream traffic is being passed while the upstream traffic waits), there is a considerable time saving due to certain characteristics of floating craft. The susceptibility of tows to the influence of the current, the stern steering characteristics of water craft, and the great length of the modern tows make it easier for one tow to follow another in line than to have two opposing tows pass each other. Therefore, the so-called "three-up and three-down" rule allows three tows moving in one direction to move through a lock in a shorter period of time than can the same number of tows that must pass each other in opposite directions. This operating rule has been applied in a number of locations in the past few years and is a departure from the traditional first arrive-first through rule.

Examples of other changed operating rules to permit faster or more maneuverable equipment to pass through first, resulting in overall improvement in commerce of a waterway, are available in a Welland Canal report prepared in 1965 by A. M. Luce and P. Sandor. Thus, it is seen that it is not necessary to build new major structures in every case to be able to pass more tonnage through a given part of the system.

It must be recognized that in some locations currents, eddies, maneuver room, and other physical factors limit the possible opportunities. At Lock and Dam 26 near St. Louis, the northern approach to the lock is very restrictive due to a projecting riverbank with a grain elevator dock. Though nonstructural potentials are good, the basic lock location is poor and there will always be an approach time penalty of some sort under the best of conditions. Zoning might have prevented the grain elevator construction but the riverbank projection would still be a problem.

There is considerable evidence that improved cooperation and coordination should be expected within and between Corps of Engineers elements. Examples have been cited of locks being operated under procedures dangerous to tows, local changes in hydraulic operating methods resulting in severe stresses on valves and structural components, and lack of reporting of such problems for technical review. These items are symptomatic of inadequate Corps internal communication and cooperation. In particular, the apparent lack of communication between operations, engineering, planning, and construction elements of the Districts often has led to extremely defensive attitudes when changes or improvements have been proposed. The talented and dedicated personnel of the Corps can do much better than in some past instances.

Corps operating improvements combined with rule changes and industry advancements could result in significant system and local benefits when they occur sequentially at busy locks. When first approached about towing industry or Corps of Engineers operating rule changes, many District personnel seem to take the attitude that the towing industry will not cooperate or that changes cannot be made. Experience has shown, however, that at several locations where problems have arisen (and good communications exist between the Corps and the towing industry) significant improvements have been accomplished through industry and Corps cooperation. The Welland Canal study again is an outstanding example of cooperation between an operating staff and the shipping industry which resulted in many more ship passages per season for small investments.

E. Potential Industry Improvements. Examples of potential improvements are also available in the towing industry. At a number of locations it is possible to see a significant movement of empty barges in both directions. If a proportion of the traffic is empty barges, then commodity flow can be improved through encouraging the towing industry to revise its scheduling or to share more of its equipment. This has been standard railroad practice for many years. Obviously, if all tows that pass a given point contain loaded barges whereas in the past some were empty, the tonnage passed is immediately increased.

There are some equipment improvements which have become available in recent years that can significantly improve the towing industry's ability to maneuver through tight places. Examples of these are radar for poor weather movement, larger towboat engines for increased control and maneuverability, addition of so-called "bow-steerers" which are small propulsion units at the bow of a tow that increase the tow maneuverability, and many other items. The Lower Mississippi traffic can tie up for the few days a year of severe fog in that area, but other portions of the waterway are not so fortunate with regard to weather delays.

There is considerable evidence that improvements in the training of river pilots would lead to improved operations. There are examples of forward-looking towboat companies which hire and use extremely well qualified pilots; such companies also tend to use towboats equipped with modern communications equipment. Their tows frequently move into and through lock systems much faster than others.

The towing industry has benefited from the disappearance of commercial passenger traffic from the rivers. Legislation provides that commercial passenger boats have lock priority over all commodity traffic, and tows often had to wait while passenger boats utilized lock facilities in past years.

There appears to be considerable realization by the industry that new approaches to traffic improvements are necessary, and that there must be better cooperation among themselves as well as with Corps agencies if the inland waterways are to continue to serve as an important element of

the national transportation system. This realization should also provide a new climate of cooperation which might not have been possible under the conditions of 15 or 20 years ago. In addition, there have been many improvements and changes in the Corps operating policies which, when combined with industry's improved understanding of the problems, may lead us to significant nonstructural improvements instead of new construction.

Of primary interest to any segment of the inland waterways system is the cost of improvements or changes, and who will pay for them. Very careful consideration should be given to the cost application aspects of any recommended change or improvement. In some cases it may be found that industry's refusal to accept a small additional cost, such as for "bow-steerers" to be used in a difficult approach or reach of the river, could result in a very large public expenditure through major construction of a new lock or approach. The effect here is that of suboptimization, the minimizing of one function (cost of operation by industry) within excessively narrow restraints (industry costs only). There is a great danger of being trapped into inefficient investments by such considerations.

F. <u>Potential Commodity Flow Improvements.</u> An extreme example of a nonstructural change would be the deliberate transfer of cargoes to other modes of transport to temporarily alleviate particularly troublesome conditions in a given location. This might be likened to a major detour in a highway system. This is obviously unacceptable to the towboat operator who would lose his business. It must, however, be considered as one of the reasonable alternatives to an unusually large investment at a given time or place when the system is considered in terms of national values and costs to all consumers and taxpayers.

There does not appear to be much opportunity for commodity flow adjustments under this type of study.

G. <u>Applicability of Improvements.</u> Potential nonstructural or low cost improvements discussed herein can be divided into categories of immediate application and longer term developments as follows.

<u>Immediate application:</u>

1. Change rules at busy locations so that tows arrive at an initial point <u>ready for continuous movement</u> through the lock without splitting, set over, or other rearrangement. Waiting line or lock entry permission to be denied to tows which cannot move through without change.

2. Require tows to move to a release point clear of the next approaching tow to be locked prior to rearrangement.

3. Increase staffing at busy locks to have an operator at all controls full time for the heaviest traffic periods. Assisting personnel to adjust dams and clear debris from intake ports are also necessary at these busy times.

4. Study and improve lock operations to gain all of the time possible at busy locations.

5. Use existing lock simulation models to evaluate potential improvements and identify best areas for improvement studies.

6. Establish special traffic control areas to provide total river area control in the most restrictive traffic locations.

Longer term applicability:

1. Centralize and automate controls to improve lock operations and trade automation cost for staffing.

2. Provide tie up cells, approach walls, current improvement dikes, debris protection, and other low cost structures at selected locations.

3. Make system interaction evaluations of delay reductions to measure impact on other locations.

4. Require improved maneuverability of tows in restricted approaches or difficult reaches.

5. Require training, licensing, and navigation aid improvements of the towing industry.

V. CONCLUSIONS

Nonstructural improvements are powerful alternatives to immediate heavy investment for many locations. In the present situation, with shortages of available Federal funds to be applied to the inland waterways, a thorough study will identify those areas where nonstructural or low cost changes may be adequate for the projected traffic increases over a considerable time frame. We should be able to improve our allocation of resources to those locations which need immediate construction while using nonstructural improvements to keep the remainder of the system viable. This study of the nonstructural alternative improvements in the inland waterways system leads to the distinct conclusions that:

A. Nonstructural improvements have already had significant localized effects for improved passage of waterborne commerce.

B. There is a potential for greater improvements in the passage of waterborne commerce through further systemwide and local study and application of these principles.

C. The systems approach should be applied to the analysis of such changes to assess what low cost actions would be most beneficial locally and systemwide.

VI. RECOMMENDED ACTIONS

To carry out the objectives of this portion of the study it is recommended that:

A. The Director of Civil Works expand this study of possible nonstructural improvements so that these types of improvements may become a standard part of the operating and management system for the future. Improved cooperation between functional staffs and various elements of Corps agencies is necessary for these concepts to work well.

B. Any proposed nonstructural change be evaluated in terms of its impact on the system as well as the locality where it may be imposed. The impact of such changes can best be evaluated at the present time through the use of simulation models discussed in other parts of this study.

C. The Directorate of Civil Works fix the staff responsibility to use and expand the Corps understanding of the important value of these nonstructural or low cost type improvements. The Waterways Experiment Station has the expertise and computer facilities for system and project type studies of this type in support of the Districts, Divisions, and OCE.

D. A study of the application of the full spectrum of nonstructural factors be required prior to major waterways construction expenditures under any authority. Lock and Dam 26 in the Lower Mississippi Valley Division, Locks and Dams 52 and 53 in the Ohio River Division, and other pending projects should be studied immediately.

E. Successful examples of improvements in procedures be widely distributed for potential Corps use in fostering full Corps/industry cooperation.

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APPENDIX A: THE PHYSICAL WATERWAY

I. GENERAL

The physical waterway is a complex of natural and improved sections. Portions of the Mississippi River flow freely, while most of its tributaries are dammed and/or canalized. This part of the study will direct attention primarily to those portions of the waterway which have been improved or which contain man-made obstructions such as bridge piers. Many problems of siting of a lock and dam and its relation to the river are associated with items of major capital investment and are discussed elsewhere in the study. A waterway's traffic capacity is a function of the properties of the river cross section, currents, weather, the alignment of the main channel, and the configuration of the tows that operate on the river.

II. OHIO RIVER WAITING PROBLEMS

In response to a phone call on 25 Nov 1970, Mr. Alan Chandler, Ohio River Division, provided the information in table N-A-1 with respect to average tow waits at two or three busy spots on the Ohio River. Information was not available on queue lengths.

Table N-A-1

Lock No.	Year	No. of Lockage Days (1), (2)	No. of Vessels (2) per day	Wait (2) per Vessel, min	Average Service (2) Time, min
50	1967	172	16	74	59
	1968	177	15	88	62
	1969	127	15	56	60
51	1967	124	15	54	57
	1968	142	16	69	61
52	1960	46	17	36	46
	1964	51	18	58	50
	1965	35	18	127	64
53	1967	23	17	90	58
	1968	65	18	128	55

Note: (1) Each of the referenced dams has center sections which can be lowered in times of high flows to permit relatively open river navigation. Therefore, these figures denote number of days/year that locking was necessary.

(2) Mr. Chandler said that these figures were averages of daily averages and are seasonal, depending on flow conditions.

There are many other examples of severe traffic conditions available.

III. INITIAL SUMMARY OF ST. LOUIS DISTRICT'S "SWITCH BOAT" TEST

Lock and Dam 26 has experienced increasing tow traffic for several years. Messrs. A. G. Eickhorst and R. A. Burke reported that tonnage in calendar year 1970 has been at least 10 percent greater than that in 1969. Many tows that arrive at the lock are too long to pass through in one lockage. They are disassembled and locked through in two or more sections. Because of separation and reassembly time in the lock approaches, a long tow takes more than twice as much time as two tows that each require single lockage. The "switch boat" test consisted of providing an extra towboat to handle split tows through the locks throughout October.

For comparison, time delays for the 768 tows passing through the lock in the month of August 1970 are shown in fig. N-A-1.

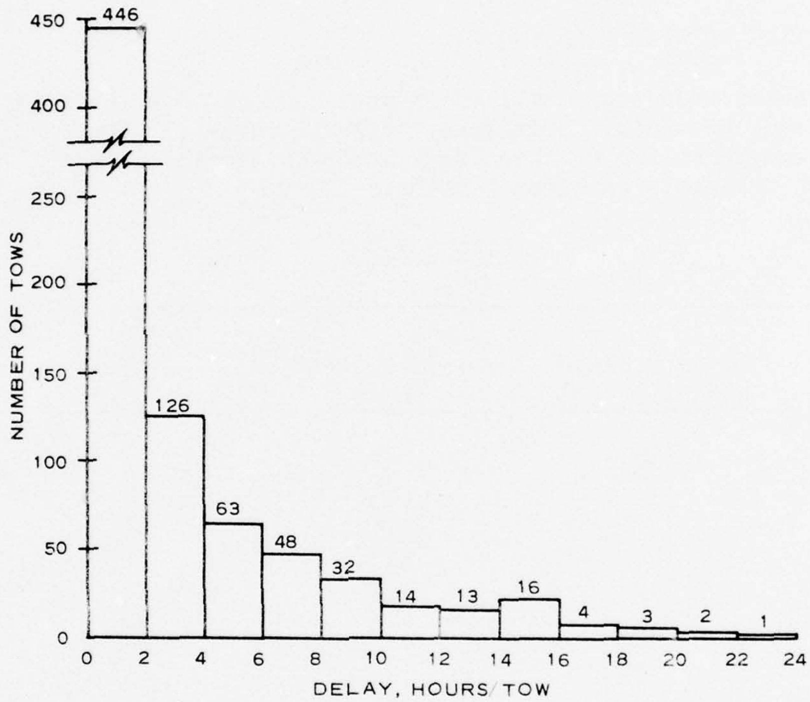

Fig. N-A-1. Time delays for tows passing through Lock and Dam 26, St. Louis District, August 1970

The weighted average delay for these data is 3.31 hours per tow. Detailed data breakdowns were not available for October at the time this report was being prepared but October 1970 had the largest tonnage passed in any month of record. Conservative interpretation of preliminary test results shows a saving of approximately $100,000 to the industry. This is based upon an estimating factor of $80.00 per 3000-horsepower towboat hour of operation with a nine-barge configuration. There were no waiting lines except for one or two isolated cases in the month. The cost to the District was

$26,000 for the 835 tows assisted. The above considerations did not include the benefits to commodity user or shippers. It is further estimated that over 90 percent of the time, during the peak summer shipping season, tows were waiting in line at Lock 26.

A complete report is being prepared by the above-named gentlemen of the St. Louis District.

IV. WAITING LINES

An example of the effect of minor changes in service times on queue lengths and waiting times is shown in figs. N-A-2 and N-A-3. Results are based on assuming Poisson arrivals and exponential service times (Sasieni, et al., page 133).

Fig. N-A-2 results are plotted from solution of

$$E(w) = \frac{\lambda}{\mu(\mu - \lambda)}$$

where $E(w)$ = average waiting time (min)
λ = mean arrival rate (arrivals/min)
μ = mean service rate (service/min)

The equation is valid only when $\mu > \lambda$. The important point in fig. N-A-2 is that a decrease in service time will result in a proportionately larger decrease in waiting time. This proportionate decrease in wait time will become larger as the arrival rate increases.

Fig. N-A-3 results are plotted from solution of

$$E(m) = \frac{\lambda^2}{\mu(\mu - \lambda)}$$

where $E(m)$ = average queue length

The equation is valid only when $\mu > \lambda$. Again, we note that a decrease in service time results in a proportionately larger decrease in average queue length, particularly at higher arrival rates.

A table of examples for sample delay reductions is given in table N-A-2 for comparison and evaluation.

Table N-A-2

Potential Reduction Benefits Based Upon Figs. N-A-2 and N-A-3

Avg No. of Arrivals tows/day	Service Time min	Avg Delay min	Reduction in Avg Delay min	Avg Queue Length tows	Reduction in Avg Queue Length tows	% Reductions		
						Service Times	Waiting Times	Queue Lengths
17	64	200	--	2.3	--	--	--	--
17	58	126	74	1.5	0.8	9.4	37.0	35.0
17	50	72	128	0.9	1.4	22.0	64.0	61.0
12	64	73	--	0.6	--	--	--	--
12	58	54	19	0.5	0.1	9.4	26.0	16.7
12	50	36	37	0.3	0.3	22.0	50.0	50.0

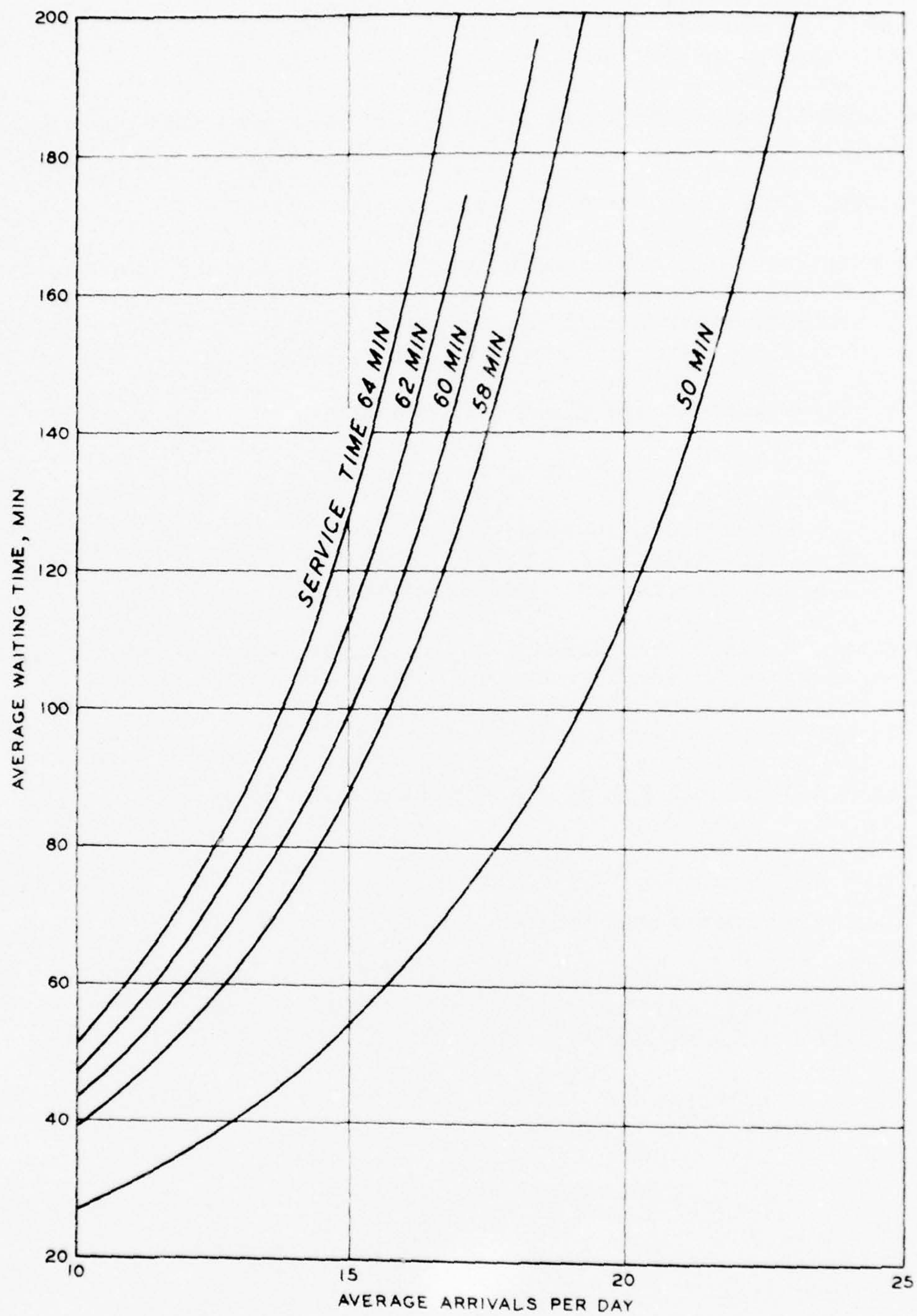

Fig. N-A-2. Average waiting times as a function of service time and arrival rates assuming Poisson arrivals and exponential service times

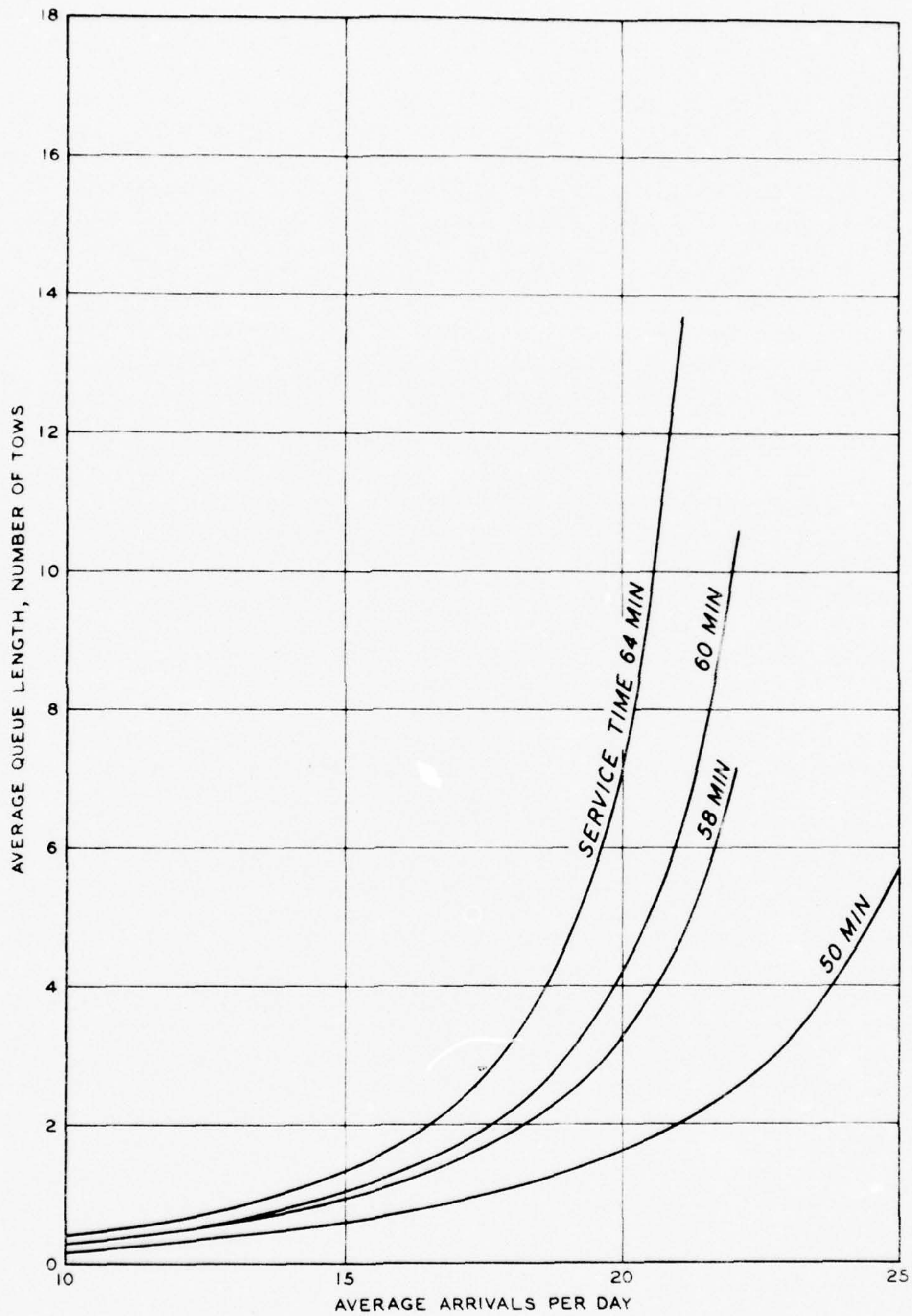

Fig. N-A-3. Average queue lengths as a function of service time and arrival rates assuming Poisson arrivals and exponential service times

V. STAFFING AND PEOPLE

A lock and dam usually costs more than $100,000,000 in capital investment. For many years it was acceptable to have minimum staffing at locks. Also, it appears that the position of lock master was a very good job in terms of pay, authority, and responsibility. It appears that lock staffing has not kept pace with the growth in requirements, investment, potential for interruption of traffic, or damage possibilities. An enclosed comment indicates that lock staffing in one District follows approximately the same pattern as it did ten or more years ago. Hiring of personnel has not been permitted at a particular lock, though extra positions have been authorized. The allocation of personnel resources for lock operation under a full traffic condition appears to need improvement in both quantity of authorized personnel and the grade of the position to insure that modern up-to-date operations and coordination may be carried on. An alternative to numbers of personnel is automation and control centralization.

An example of a breakdown of communications is available in a recently constructed lock in the South. Model studies made after lock construction showed that depending on the tow's location under certain conditions, navigation into the lock would be very difficult. This was reported to the District concerned who, in turn, related that several tows already had run aground under these conditions. Upon later query as to what had been done to notify the commercial and private waterway users about the problem area, it was stated that no announcement had been made because of possible adverse criticism concerning the lock location.

It has been the experience of a number of knowledgeable observers that a great number of locks and their filling systems are not operated in accordance with their design. Technical personnel making inspection visits to several such projects have noticed problems such as dangerous air blowouts in water passages, lock chamber surges which move tows toward the gates under overstressed hawsers, excessive vibrations in valves and structures, and other such dangerous hydraulic phenomena. Considering the natural forces and volumes, the investment, and the potential for accidents, each lock should have an operating procedure prominently displayed before or above the place where the operator handles controls. Such operating guides generally do not exist. The correct sequence of operations for a variety of conditions, both usual and emergency, should be displayed. Trouble indicators and the potential problem behind them should be displayed so that emergency procedures or requests for technical assistance can be initiated when serious problems arise. Improper valve operation of filling systems can cause dangerous disturbances of tows or pleasure craft in the lock, trapping of air and blowing off of gratings, water hammer, and many other such potentially destructive problems. In particular, some filling systems require very close coordination of valve operations to handle large amounts of water efficiently and rapidly and for the safety of the craft in the locks. Such problems are frequently not recognized or, if recognized, are not brought to the attention of technical personnel who can provide assistance.

VI. EQUIPMENT AND SERVICES

A number of improvements have been made at various locks which tend to reduce the time that the lock is servicing a tow. For some years, various locks have used a cable assembly to pull the first half of a split tow out of a lock, thus permitting the towboat and second half to follow through immediately behind. In locations where tows longer than the lock do appear but there is no long waiting line, such devices are helpful. At locations such as Lock and Dam 26 in the St. Louis District, the growth of traffic has overtaken the advantage afforded by such a device. There are times when tow reassembly in the exit channel blocks an opposite direction tow from using the lock, thus increasing the effective service time and probably increasing the queue length.

Where heavy traffic conditions occur frequently, it has been demonstrated that the use of an extra towboat at the lock has been very effective in passing traffic. The Industrial Canal Lock in New Orleans has had an operating rule which requires that the second half of a split tow move to the end of a waiting line. As a result, the towing industry pays for the use of an extra towboat to carry through the front half of a split tow at the same time. In view of the experience at the Industrial Canal Lock and at Lock and Dam 26, the use of an extra towboat should be very thoroughly investigated as an immediate opportunity for large returns at small cost. It is recommended that this is properly a towing industry charge as has been the experience at the Industrial Canal Lock in New Orleans.

There is a suggestion that a system of wheeled, movable mooring posts might be useful in moving tows into, through, and out of locks. By providing positive control to the tow, the reduction in time, particularly for large tows, and the consequent reduction in damage to walls and corners appear to make this a worthwhile item for consideration at some locations. The effect here would be that of providing cable-operated miniature locomotives such as those that assist ships through the locks in the Panama Canal.

From observations of damage at Lock and Dam 27 and other locations, there may be an opportunity to improve passage through a lock by providing replaceable fenders, energy absorbers, and/or rolling fenders at critical points on the lock walls.

At places where recreational craft appear in considerable quantities, the introduction of separate handling facilities may be worthwhile. Such items could be canvas slings to lift the craft from one level to another, separate small locks out of the main navigation channel, or an inclined plane moving lock such as has been used in Europe and in the early canal development in the United States. Separation of recreational traffic from towboat traffic would not only be of assistance in moving waterborne commerce, but would also appear to be a safety improvement. Again, the benefits versus the costs at a given location must be studied in detail.

Locks have been designed for many years with the idea that personnel should visually inspect the entrance, exits, and outlet ports before operating gates or valves. As a results, controls in many places are located on opposite ends of 600 to 1200 ft of lock wall and sometimes one person is required to move from one end to the other on foot or with scooters to operate the lock. Considering modern control and industrial management processes, it may be worthwhile to consolidate all controls into one location and use closed-circuit TV monitors for visual scanning. The Welland Canal improved operations through this change.

Air bubbler systems have been used to keep floating debris out of some critical locations and should be further investigated.

Outlet ports may require their own TV scanners or warning devices to indicate when a small craft may be in the area, or it may be economical to relocate the outlet port to where it can be seen from a control location or to place it along the edge of the river where water craft do not usually travel.

Another improvement which offers considerable promise would be that of automatically controlled cycling of filling and operating sequences. Rather than have a variety of controls, modern industrial facilities today provide for automatic sensing and sequencing of steps in an operation. In this manner, large valves and heavy gates can be much more carefully and properly controlled than by manual operation. This might result in faster cycle times and less damage to lock components. The cost of the automated equipment must be measured against the savings of decreased personnel, the benefits to the towing industry at a given location, and the potential longer structure life through safer operation.

VII. NAVIGATION RULES

Legislation which provides the authority for the Chief of Engineers to operate the inland waterways system appears to provide the necessary authority for Division personnel down to the lockmaster to operate under conditions necessary for the greatest benefit to all. In many cases, practices which were fairly loose under low traffic conditions may no longer be acceptable. The problem is in knowing when and where to change the rules and the gaining of acceptance of the necessity for change by the towing industry and other water users.

Rule changes can be effected and have been successfully applied in a number of locations. At Lock and Dam 26 in the St. Louis District, the locks are operated under what is known as a "three-up and three-down" rule. The characteristics of water craft, their susceptibility to currents, their stern steering characteristics, and the great length of tows require considerable maneuver room for safe passing in two directions. These characteristics have led to the multiple one-way passage as having a distinct time saving over alternate passage through locks. Other locations have used such rules. There is, at the present time, in effect a "five-up and

five-down" rule at Vermilion Lock in the New Orleans District. These one-way rules could also be modified to "three-up/five-down" depending on waiting line configurations at a given time. Study of potential waiting line buildup and system-wide effects of such rules is necessary prior to their use; some improvements may merely shift the problem and two or more locks may need coordinated study.

Other successful examples of changes in rules which resulted in major benefits to the shipping industry are available in the Welland Canal studies. In the Welland Canal careful study revealed that when a waiting line formed for any reason a slow ship would impede the progress of many ships if it were near the head of the line. When faster ships were allowed through the lock ahead of slower ships, the slower ship arrived at its destination at essentially the same time without delaying the faster vessels. The result then was a greater passage of tonnage per unit time through the entire system.

A proposed rule change mentioned by a number of people contacted during this study would be to require a tow to appear at an initial point for lockage some distance from the lock, prepared to move through without further changes in tow configuration. Tows appearing at that point would be denied waiting line position if they were not able to move through the lock without splitting the tow, rearranging barges, or other time-consuming modifications prior to entry into the lock itself. The use of the switch boat in the New Orleans Industrial Canal Lock and Lock 26 might be necessary for rapid rearrangement under such a rule. Ohio River experience shows that changes in tow configuration are frequently made by many operators as the tows move up and down the river. This particular change of rules would result in some procedure changes in the towing industry but would also result in a considerable direct benefit to the industry. Mooring cells or tie-up locations may have to be built to assist in this system.

Rules could be developed for tow size, maneuverability, and arrangement such that arrivals at an initial point for a given lock would gain priority according to their ability to move rapidly through the lock when waiting lines exist.

Any change in rules will undoubtedly be resisted by some waterway users. Considering our responsibility to operate for the greatest possible benefit, active communications and analyses of conditions should be made available to waterway users associations and the public.

VIII. MINOR CORRECTIONS THROUGH CONSTRUCTION

It was recently noted by Dr. J. L. Carroll of Pennsylvania State University that Brandon Roads Lock in the Chicago District was experiencing greatly increased filling times because of debris collection at intake ports. These partial blockages, which often double lock filling time, could be obviated through improved staffing or inlet feature redesign. A normal filling time under 15 minutes should be expected. Again, the cost of any

proposed improvements should be measured against the delays experienced under reasonably full traffic conditions at that location.

At Lock 24 in the St. Louis District a dike was constructed upstream of the lock which improved greatly the navigation conditions experienced by tows as they approached the lock. The dike enabled faster approaches and shorter service times. There is also a serious problem with drift debris at this lock, and a 100-ft extension of the dike is to be made to alleviate this problem. On the other hand, the possibility of shoaling due to dike construction in an alluvial stream cannot be ignored and should be studied for each location where a dike is proposed.

There are a number of locations where lengthening of approach walls would enable towboats to line up close to the lock entrance as they await their turn. Considerable reductions in service time can be experienced in these cases. Some European locks provide an offset waiting location close to the lock entrance. A flared-angle waiting wall may permit tows to wait close to the lock and provide passing room for the exiting tow. This type of waiting improvement requires increased tow maneuverability through the use of bow-steerers or mechanical devices such as a swinging arm from the lock wall which would grasp the tow and enable it to move out into line with the lock entrance. Such changes would eliminate the three-up and three-down rules and permit two-way tow passage for each filling and emptying of a single lock. The investment and operating cost for this modification must be measured against a wide variety of operating systems or potential improvements. This may be an economical improvement in areas of very intense two-way traffic.

In other locations, redesign or reconstruction of lock filling systems may be appropriate and, when combined with possible operating and rule changes, could postpone large investment for a number of years.

IX. WEATHER AND ENVIRONMENT

Weather factors, particularly in the winter, have a considerable effect upon waterway users, and a wide variety of navigational aids are used by the towing industry and other water craft. There is some evidence that radar does not adequately detect bridge piers or abutments and floating debris. Highly reflective radar targets could be placed on these obstructions to improve the ability to navigate at that location.

There may be a requirement to designate certain heavily trafficked reaches of the rivers or canals as special traffic control areas under procedures similar to aircraft control areas. By providing a centralized control with shore-based radar displays, it may be possible to greatly increase traffic flow during fog, snow, heavy rain, or other difficult conditions. Conversations with Vicksburg District operating personnel have established that tows presently tie up in heavy fog conditions because the few days of occurrence per year do not warrant the associated risk of traveling under such conditions. Expected traffic growth is such that this will not be a valid approach much longer.

In some locations wind has an adverse effect upon the ability of tows, especially empties, to approach locks. Corrective structural additions or revised procedures may be required. One such location is at Lock and Dam 27 in the St. Louis District; the lockmaster has movies which show significant wind effects on tows entering the lock.

In some areas, particularly coastal areas, the growth of aquatic plants and weeds may be a serious hindrance to industrial navigation and the ever-increasing number of pleasure craft using the waterways. This problem is presently under study by the Chief of Engineers.

X. COMMUNICATIONS

Many tow operators provide the latest radio equipment to enable their pilots to communicate with other boats, locks, and ports. In addition, operating crews are provided with small radio sets to improve control and response times. There have been instances at locks where an installed loud speaker system was in use to enable the lock personnel to talk to the tow personnel that when the system broke down, rather than having it repaired it was removed.

As traffic flow increases, the requirement for up-to-date navigation aids increases. Improved understanding of navigation possibilities and location of navigation aids must be an active part of the Corps administration of the waterways. Here again, radar targets might be added to the navigation aids to improve poor weather capabilities.

XI. THE GENERAL PUBLIC

In the past few years, recreational uses of waterways have increased greatly. In many locations there is a considerable weekend traffic which cannot be ignored; the general public has a right to use the waterways as well as the towing industry. As mentioned before, at some locations separate facilities should be provided to handle recreational craft. Improved communication with the boating public is desirable to ensure that the safety and operating rules are understood by all. It has been reported that in some instances craft in a lock have been left hanging by their tie-up lines as the lock was emptied. Consistent color coding of the tie-up and safety item should be considered such as a Corps-wide program for all navigation tie facilities to be painted green—no tie-up items painted red.

A small item, but a distinct hazard, is the fishing activity in the vicinity of locks and dams. Lock discharges can be very dangerous to individuals and small craft. It appears to be time for a general study of improvement of hazard protection features for small boats to include physical restriction from certain areas and reconstruction or revision of outlet conditions to minimize these hazards and their potential for interrupting lock operations.

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APPENDIX B: THE TOWING INDUSTRY

I. GENERAL

The towing industry, as a private entity, is somewhat freer than the Corps in its operation insofar as what it may or may not do. Over the years, the towing industry has adopted many changes which improved its operations. These include, for example, the wide use of twin-screw, Kort-nozzle equipped diesel towboats and the adoption of electronic shipboard navigation devices. Indeed, any industry improvement which can reduce operating costs will result either in greater direct profits or a chance to improve competitiveness through lower freight rates. It should never be felt that an unchangeable or best system has been found; there should always exist an opportunity for improvement. This would seem applicable to the towing industry today.

Given an atmosphere of complete cooperation and coordination between the Corps of Engineers, all tow operators, and all freight shippers using the waterways, it is felt that considerable increase in waterways capacity could certainly be effected. But many possibilities for increased capacity and lower costs exist entirely within the domain of the towing industry; these possibilities will be examined first in the discussion to follow.

II. IMMEDIATE IMPROVEMENT POTENTIAL

One useful device which is now being used to a limited extent is the bow steerer or "bow thruster." These independent power units mounted at the head of a long tow allow propulsion of the bow in any direction and thus greatly increase the maneuverability of an otherwise somewhat sluggish (especially at slow speeds) vehicle. While some of these units are permanently fixed to a barge and thereby dictate special care in fixing the configuration of the assembled tow, others are independent units and can be fairly easily attached to a forward barge of almost any tow. There have been various reports of tows, especially very large or underpowered ones, having considerable difficulty in executing necessary locking maneuvers. Large tows operating with small clearances in lock areas require very precise steering, and most tows are difficult to control if lock approaches and exits are complicated by crosscurrents, wind, or heavy traffic. In view of these problems frequently encountered in maneuvering tows around and into locks, it would seem that bow steerers could be economically employed to a much greater extent than they are at the present time. Such devices could also provide the towboat pilot with a much greater degree of steering flexibility and resultant safety when navigating under other adverse conditions of weather, traffic, or channel conditions, as well as greatly simplify dockings and landings.

Electronics, which are exerting an ever-increasing influence on all aspects of modern life, are becoming increasingly important to the towing industry. River navigation is hampered by darkness and adverse weather

conditions; electronic devices offer a means of reducing navigational hazards, and difficulties under such conditions. When properly used, electronic devices contribute sizable returns in terms of both safety and economy. Two-way radio allows an operator's shore base to maintain contact with the towboats for emergencies and general fleet coordination. It also allows towboat pilots to intercommunicate and learn the positions of other towboats in their areas. Echo sounders for constant depth monitoring have encountered some operational problems such as damage to sensor units from underwater debris. Given an eventual correction of these problems, such devices may find much greater use, especially on rivers where the main channel is subject to frequent shifting. Radar has become a very valuable aid to low visibility navigation. Radar in its present form has some deficiencies, such as the inability to distinguish bridge piers, but the information it does provide can be very useful; further, it can be expected that future developments such as the general use of radar targets on obstructions will eliminate many of the current shortcomings. Rate-of-swing indicators to monitor rudder response allow finer control and will probably become more important as tonnage and tow size increase and necessitate more precise rudder control. "Auto-pilots," which are actually merely devices which will maintain a given preset heading, hold great possibilities in terms of future development. In their present form, such devices are quite useful on long straight reaches and have been found to greatly reduce fuel usage as compared to human pilots because constant course variations and corrections are minimized.

Previously discussed improvements are, for the most part, ones which can be adopted by individual operators. Another opportunity for improvement could be opened up through greater cooperation among different operators. Perhaps one of the most important gains of this type could be achieved through more cooperative scheduling and sharing of equipment. The opportunity for this is evidenced by the two-way empty barge traffic noted on some reaches of the waterways system. Where empty barges are similar in these instances, there appears to be no reason other than lack of willingness to share equipment that prevents the movement of only full barges of that type in at least one direction. The savings in wasted energy as well as the resultant share of gains to overall system efficiency should more than offset any associated increase in management costs. Along with this general idea goes the possibility that a sort of industry-wide clearinghouse could be established to keep track of waterways equipment.

Several types of highly efficient automated cargo handling equipment have been put into use for handling bulk materials; further advances in this area can be expected. A major shift to containerization within the barge industry can also be expected, especially as increased emphasis on intermodal transportation coordination develops. Shipper ownership of barges, especially dedicated equipment, sometimes restricts their full time utilization, but this may be resolved through cooperative agreements. Another concept aimed at reducing empty barge traffic would be the development of hybrid equipment types where the nature of the cargo permits. As an example, the adaptation of some sort of inflatable bladder would

allow a barge to transport liquids within the bladder on trips in one direction while hauling general dry cargo otherwise on the return trip.

There are many more opportunities for the industry to improve itself through closer cooperation of individual operators. Assistance in the determination of the maximum practical size of tows to be used on the waterways as well as regulation of such size once it is determined might be among the areas in which industry-wide cooperation could effect important improvements. Even with all of the available electronic and special devices to simplify navigation, the most modern of towboats is far from automatic. As such, their operation requires well trained pilots. An agency for the training of towboat pilots has recently been established along the Arkansas River; such activities should be well supported and encouraged. Along with this might go pilot and equipment licensing and inspection. It may be questioned whether the individual tow operators would institute such restrictions as these upon their own operations, but if they realized that such measures would be beneficial to a good majority of the operators, then it should be possible to make a majority of operators accept them. A logical industry-wide type of agency to promote greater cooperation among various operators might be found in the American Waterways Operators, Inc.

Previous discussion has dealt primarily with improvements which require no new technology. Many of them could be applied with a minimum of special planning or preparation, and few would require what would be considered a major investment on the part of the barge or towboat owner. Any investment involved in such items should be recoverable in benefits over a relatively short time.

III. FUTURE IMPROVEMENT POTENTIAL

Looking at the not too distant future, there are several possible ideas which should improve the towing industry. Such improvements would require more time to develop and adopt than those previously discussed and they might be more costly and thus require a longer depreciation period to realize profitability. One idea which would seemingly be worthwhile and highly profitable would be the development of a simple, quick-operating, and universally adaptable coupler for joining barges. At the present time, moorings and barge couplings are made by traditionally effective but slow methods which are quite time-consuming when tows must be disassembled and reassembled. Mounted on all sides of all barges, the coupling devices suggested could greatly speed up the assembly and disassembly operations of tows. Considering the time this would save during pickup and delivery switching and particularly in breaking tows for multiple lockages (where a few minutes saved by each tow greatly increases lock capacity), such devices should prove vastly more economical than traditional rigging and lashings.

A towboat system that has been used in Europe and which might find favorable application in this country is the "automotive coupled unit." In this system, each tow is propelled by two independent towboats whose

controls can however be coupled and operated by a single pilot in the master towboat. This system is somewhat more maneuverable than a single towboat system because of the spacing between the two boats which push side by side at the stern of the tow. The biggest advantage in such a combination though would be the convenience of having two towboats available for switching operations. The tow could normally be operated by a single pilot who could be assisted by special pilots permanently stationed at locks and ports. When double lockages are necessary, the tow could be split up and remade far enough from the lock to avoid any traffic interference and the two independent parts of the tow could pass through the lock in the same manner as any single-lockage tow. Thus the need for a local switchboat at each location would be eliminated and the full capability of each towboat could be utilized at all times.

In the area of long term industry planning, many types of hardware changes are possible to reduce costs. Improvements in barge construction and structural systems can be expected to reduce fabrication and maintenance costs and to reduce barge tare weights. Special consideration of hydraulic and aerodynamic characteristics of barges may result in lower drag forces on barges and improved handling under rough current and wind conditions. In applications where the one-way movement of empty barges is unavoidable, it may be possible to stack empty barges one on top of another and cut the waterway area of the tow in half. Although this would require complex handling equipment, hydraulic drag would be reduced, and double lockages could be eliminated at most places on the return trip of tows which required double lockages in their loaded configuration. Further increases in towboat horsepower as well as improved steering and propulsion methods are also likely.

The use of better traffic monitoring and coordination has been mentioned, but in terms of long range planning, this concept should be greatly expanded and improved. The progress made by the railroads in recent years in the areas of automatic electronic traffic monitoring and control should serve as an example of some of the possibilities in this area. The future possibility of fully automated barge navigation certainly exists; it may be by total electronic control and guidance, or underwater rails may either physically guide floating craft or provide directional information to sensors which control the craft's steering. Such concepts may first be adopted in difficult river reaches and lock approaches. Continuous monitoring and updating of lock operation, fleet scheduling, and commodity flow could greatly increase the realized capacity of the waterways.

The realization of any improvement in waterways operation requires both planning and appropriate action. As is the case in many industries, many operators in the towing industry have not planned and do not plan carefully for future improvement. Very few have been sufficiently forward-looking to fully realize the potential savings possible from currently available improvements. Greater standardization in all areas of tow industry operation, a much greater effort in the area of long term planning, and better cooperation between elements of the waterways system would go far in benefiting the barge tow industry and improving waterways capacity.

APPENDIX C: COMMODITY SYSTEM

Carr (page N-F-40) states that over half of all barge cargo tonnage consists of petroleum (38%) and coal (19%). The remaining cargo includes primarily rock products, sea shells, lumber, grain, chemicals, iron and steel, limestone, sulphur, coal tar products, soybeans, pulpwood, fertilizer, and paper products. The nature of these cargoes exemplifies the strong attraction of barge transportation for bulk type cargoes.

There are complex problems of a regional and national character associated with commodities, their flow through the transportation system, shipping practices, port facilities, and port competition and many other important considerations. In particular, the distribution of commodity transportation amongst the various modes such as rail, waterways, truck, and even air has an important effect upon the inland waterways system and the other transportation elements. This "modal split" problem is the subject of considerable discussion, conjecture, prognostication, and government regulatory considerations. There is a considerable effect due to the seasonal nature of commodity production by crops as well as the weather effects in the northern parts of the nation.

One advantage of the inland waterways system is that commodities can come to almost any part of a reach that may be convenient or economical for shipping. In a sense, portions of the river systems may be considered to be linear port systems; this means that development of port facilities need not necessarily be concentrated into a few highly congested locations. On the other hand, there could be disadvantage in use of a sprawling type development up and down the waterways causing serious congestion due to a multiplicity of port and docking facilities and the consequent slowdown of traffic in such areas. Flexibility of development along a waterway must be tempered by zoning or congestion considerations if we are to have reasonably efficient systems for getting our commodities to the ports and moving them on the waterways.

Dedicated equipment is that equipment which is designed to carry one commodity, usually in one direction. Petroleum products are transported in tank barges and very often returned empty. Containerized cargoes are now coming into prominence and LASH (Lighter Aboard Ship) activities are presently carried on between St. Louis and New Orleans. This type of cargo handling may bring commodities to the waterway which have traveled in the past by rail or truck. Investment, of course, in such specialized equipment for port facilities and the oceangoing vessels is a considerable expense. It appears that there is much interest in this type of activity along certain waterways, and it can be expected that more expensive lower volume cargoes will move in increasing amounts in the coming years. The expectation here is that these commodities will move between large industrial type ports rather than from more remote locations. Incompatibility of fluids has been overcome in oceangoing tankers through specialized cleaning procedures. However, the two-way transportation of different

fluids in tanker barges has not been developed so far. It is not expected that these considerations will provide major changes in commodity flow patterns for the foreseeable future though there may very well be growth of these activities along with growth of the more traditional waterborne commerce.

Commodity movements are often competitive under different modes of transport. In recent years the unit train concept has become a major competition for movement of bulk cargoes which were formerly moved by water. If properly administered through governmental activities, this competition will operate to keep waterway costs as low as possible. A major delay location on the waterway may very well force some commodities to be moved overland not necessarily because it is cheaper but because the prices are close and delivery schedules can be better met. Though shift of commodities to other forms of transport could be forced by deliberate lack of facility improvements on the waterways, it is not considered reasonable that such overt policies would come about. Modal shifts could very well come about due to severe constrictions in some locations where overland transport may involve a shorter distance than round-about waterway routes.

At the present time there does not appear to be much opportunity for passage of more tonnage over the inland waterways through immediate modifications of the commodity flow system.

APPENDIX D: INTERACTIONS

Rules under which the inland waterways system operates should provide for a broad spectrum of benefits to the water-using public that should be consistently applied, and where changes or options are required, specific guidance must be provided. The principal points where rules have an impact on the towing industry are at locks, but there are some other location effects also. Apparently tows are required to pass Cincinnati at lower speeds due to the effect upon smaller water craft. This type of rule reflects our concern for the safety of the pleasure boating public versus the needs of the waterborne commerce segment. Lock operating personnel must have the cooperation of the towing industry and general boating public to provide for safe and rapid transit through their facilities. Changes of rules or temporary restrictions due to heavy traffic, ice, bad weather, and other such factors must be made known to water users in every way possible.

Tow sizes may vary for different parts of a river system, different seasons, the facilities available, and to meet the needs of the business of moving commodities. In many instances it appears that tow sizes are determined by the operator and changes are made at locks in a manner which causes delays or disturbances to the steady flow of traffic. It may be very desirable in busy locations to require that tows appear at an initial point for lockage, prepared to move through the lock without rearrangement of barge or towboat location. This rather simple interaction of operating procedures with Corps of Engineers responsibilities to pass the most traffic as rapidly as possible should be very carefully studied and applied in appropriate locations. The results should be more rapid movement of the entire flow of traffic through the lock system and consequent benefits to the industry and eventually to the consuming public.

Tows should be provided with the proper number of personnel to enable them to operate safely through locks. For most tows today, deck personnel should be provided to handle a reasonable number of lines simultaneously so that lock operation may begin as soon as possible. Some instances have been reported where one deck hand must move up and down and across a large tow to secure a number of lines. In many cases locking operations cannot proceed until this tow is well secured. At the same time there should be sufficient staffing of the lock to pass the necessary lines and operate all the equipment as rapidly as possible. There must be a balanced force to enable rapid passage of traffic at the busiest times though we may be willing to accept less than optimum staffing at slack periods. At many locations personnel must be provided to man a continuous radio watch.

There are some locations which can only pass the necessary traffic under intensive waterway management procedures. This procedure would be similar to an air traffic control area surrounding a busy complex of airports. This intensive management area would have a centralized control over one or more locks and river entrances to insure that they operate in

the best coordination. A system to identify traffic coming into this area and predict problems prior to their occurrence would be essential. Such activities as reporting of positions, changes of course, and exit from the special area would be required of tows. Ground-based radar reporting points, entrance and exit reports, and powerful communications are required to make such centers effective. The area surrounding Locks and Dams 52 and 53 on the lower Ohio River should be considered for such comprehensive control as an alternative to future temporary construction. This type of activity may be applied intermittently in busy locations when heavy traffic builds up or bad weather appears. It may also serve to pass more traffic through very difficult and restrictive reaches of the rivers not necessarily at locks.

Most improvements that are concerned with the system as it exists require widespread cooperation between the operating staff and the water user. The best efforts of one segment can be frustrated by a lack of cooperation or understanding on the part of another segment. This can occur in any human endeavor. It requires that complete information as to the necessity and the alternatives be thoroughly understood.

APPENDIX E: QUESTIONNAIRE AND RESPONSES THERETO

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL	SUBJECT
WESVR	Inefficiencies and Potential Nonstructural Improvements in Inland Waterways Operations

TO Division Engr Representatives Inland Waterways Systems Analysis Task Group | FROM LTC F. M. Anklam | DATE 24 Sep 70 | CMT 1

1. In the 8 September 1970 memorandum from BG Groves, I was assigned the above subject as my input to the study group report.

2. The inclosed questionnaire is designed to gather information from the Division and/or District staffs on the above subject. Please distribute copies to appropriate Operations, Planning, and Engineering personnel for return to me by 20 October 1970. They may be collected by you or returned directly to me as best fits your situation. Reproduction for District or lower distribution is appropriate if desired. I would appreciate your keeping track of responders in your Division.

3. I will be happy to receive information on this subject from any source interested in contributing to the Task Group efforts.

F. M. ANKLAM
LTC, CE
Member, IWSATG

1 Incl
as

CF:
Mr. J. A. Rhodes, OCE
Members, Task Group

DA FORM 1 FEB 62 2496 REPLACES DD FORM 96, EXISTING SUPPLIES OF WHICH WILL BE ISSUED AND USED UNTIL 1 FEB 63 UNLESS SOONER EXHAUSTED.

GPO : 1968 O - 333-400

24 September 1970

CIVIL WORKS TASK GROUP FOR INLAND
WATERWAYS SYSTEMS ANALYSIS

SUBJECT: Information Pertaining to Inefficiencies and Potential Nonstructural Improvements in Inland Waterways Operations

1. The above-named Task Group was formed to study the application of systems analysis concepts to the inland waterways transportation system. A logical portion of the study concerns potential improvements in areas such as:

a. Procedural changes
b. Staffing improvements
c. Traffic controls
d. Changes in lock operation
e. Scheduling of tows according to size, maneuverability, etc.
f. Improved utilization of barges and/or towboats
g. Providing tugs or other assistance to units too large for one lockage
h. Bad weather modifications
i. Equipment improvements for the towing industry
j. Port developments and changes
k. Handling of pleasure crafts

2. Please outline how the above nonstructural (or minor expenditure) items may be changed in any way to better serve our nation through an improved inland waterways transportation system. The list may be incomplete, additional items are welcome as appropriate. Examples of successful and unsuccessful attempts to improve operations by these and other means are desired. It is recognized that items may have potential in one location but not another.

3. Submitted material will be analyzed and reported upon for potential Corps-wide distribution as appropriate. In order to facilitate correlation and cross referencing, please use the format given in the attached appendix.

4. Please return to LTC Frederick M. Anklam, Deputy Director, USA Engineer Waterways Experiment Station, Vicksburg, Miss. 39180, by 20 October 1970 to enable meeting the Study Group's report deadline. Later submissions are welcome but may not necessarily be included in the initial report.
Telephone numbers: 601, 636-3111
FTS: 601, 636-2592
AUTOVON: Through Vicksburg District, 733-1142

INCL 1

SAMPLE FORMAT

ITEM	DESCRIPTION	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Traffic control at locks	At lock XYZ, a rule of "three up and then three down" has been applied in heavy traffic.	Allowing the second and then third tow to approach the entry gate from the same direction saves more time than having an upstream tow stand clear for the existing downstream tow, then enter in the lock from a distance. The cycle for three one-way tows is __ minutes vs __ minutes for two-way entry in sequence.	System appears to work fine--minimum trouble.
Split-tow assistance	A cable arrangement pulls the first half of a split tow out of the lock.	This assistance avoids attendant delays in tying up the first half, recycling the towboat, etc.	Works fine here--requires extra man.
Encourage improved use of available equipment	Penalize tows with many empties.	On the ___ river, it is regularly noted that there are extensive empty barges, often both ways, indicating a lack of renting or sharing of available equipment. Increased ton miles would result from increased use of these empties.	Anticipate resistance by operators until they get use to the idea--railroads do this all the time.

ENGBR(24 Sep 70)
SUBJECT: Inefficiencies and Potential Nonstructural Improvements in Inland Waterways Operations

TO: LTC F. M. Anklam FROM: R. K. Adams, Chief, Evaluation Div. DATE: 14 Oct 70 Adams/sw/31238 CMT 2

1. On several occasions during the last two years I have had the opportunity of taking extended trips on towboats at the invitation of operators. On one such trip I traveled the Upper Mississippi River from St. Paul, Minnesota, to Quincy, Illinois, and on another occasion I traveled the Illinois Waterway between Starved Rock Lock and Dam, Illinois, and St. Louis, Missouri. The observations made in subsequent paragraphs are necessarily generalized since I do not have specific technical knowledge of conditions at individual locks.

2. An obvious deficiency of navigation on the Upper Mississippi relates to the placement of locks and dams at the wrong locations. These structures were constructed in the 30's and apparently little consideration was given to operational problems when they were sited. Lock and Dam 18 on the Upper Mississippi stands out in my mind as a horrible example. There was a very bad outdraft (high water) that required the downbound tows to flank in, keeping the stern close to shore and pivoting the lead barges into the guidewall. Needless to say, the approach to the lock took considerable time--32 minutes from the time we received the green light till we touched the guidewall. Similar conditions exist at other locks and dams on the Upper Mississippi and other waterways--the Gallipolis Lock and Dam on the Ohio River is another example. Once the locks are sited there is little that can be done except to extend the guidewalls, provide mooring cells, and/or tug assistance.

3. Power winches are in use on most locks for pulling out the first section of a double. This should be a standard requirement at all locks since the recycling of towboats is time consuming and therefore costly. Several locks now have traveling bits which are time saving improvements.

4. For congested locks, the three up, three down procedure seems to be working well. However, no one really knows if three is the right number. It probably should vary from place to place and from time to time. On my last trip down the Mississippi River, we arrived at Lock and Dam 26 at 1945 and became 7th in line. The lockmaster was using the three up and down system at that time. We locked through at 0530. This delay of about 10 hours might have been reduced with a five up and down procedure.

5. Lock-size tows can increase the efficiency of locks to a great extent. It is understood that Lock and Dam 26, Mississippi River, and certain locks in the New Orleans District are now locking through the first section of a double and making the second section get back in line. This should increase the tonnage being locked through during a given period and will require the operators to schedule lock-sized tows in order to increase their own efficiency.

6. I was generally impressed with the efficiency of Corps personnel at the various locks. I cannot think of any specific personnel procedural change that should be made to increase lock efficiency. Some locks use scooters and bicycles for personnel movements along lock walls while at other locks the personnel walk. I doubt if efficiency is increased much one way or the other--except for worker morale.

7. We did not have any problems with recreational craft at any of the locks, although I understand from talking to the pilots and lockmasters that a serious problem does exist on weekends. It appears that our planning should give serious consideration to the provision of auxiliary locks or other devices for accommodating recreational craft.

8. One peripheral issue has to do with bridge piers and channel alignment. The bridges at North Peoria, Illinois, the railroad bridge at Savannah, Illinois, and the bridges at Clinton, Iowa, all pose problems for tows because of their positioning in such a way as to make navigation difficult. More attention should be given for permits on new bridges, and consideration should be given to alteration of obstructive bridges under Truman-Hobbs.

Russell K. Adams

1 Incl
nc

RUSSELL K. ADAMS
Chief, Evaluation Division
Board of Engineers for Rivers
and Harbors

Copy furnished:
Mr. J. A. Rhodes, OCE

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P. O. BOX 60267
NEW ORLEANS, LOUISIANA 70160

LMNOD-NM

8 October 1970

SUBJECT: Potential Nonstructural Improvements in Inland Waterways Operations

Division Engineer, Lower Mississippi Valley
ATTN: LMVCO-O

1. Reference is made to letter LMVCO-O, dated 30 September 1970, subject as above.

2. Information requested is herewith furnished.

FOR THE DISTRICT ENGINEER:

1 Incl
As stated

Hugh L. Brownlee
HUGH L. BROWNLEE
Chief, Operations Division

ITEM	DESCRIPTION	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Traffic control at locks.	At Inner Harbor Navigation Canal Lock and Vermilion Lock, five successive lockings are made to the east, and five successive lockings to the west during periods of heavy congestion.	This procedure permits the vessels in the second through fifth lockings to come onto the guidewall and enter the lock without delay. On the second through the fifth lockings, an average of 10 minutes is saved at Inner Harbor Navigation Canal Lock, and 7 minutes are saved at Vermilion.	Procedure is time saving.

The District Engineer
U. S. Army Engineer District, New Orleans
P. O. Box 60267
New Orleans, Louisiana, 70160

The District Engineer
U. S. Army Engineer District, New Orleans
P. O. Box 60267
New Orleans, Louisiana 70160

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Tow Operation	Telephone conversation. Information from Dr. J. L. Carroll to LTC F. M. Anklam.	Notes that towing industry does not always utilize its equipment to the best advantage--at some locations on the Ill. waterway, plenty of two way empty barge traffic has been noticed. Swing arounds to get a towboat back to pick up second half of double lockage tows wastes time at busy locks (dummy lockages). Suggests that future tow makeup may change and hence may or may not fit present locks. Questions where conformance of tow size to lock should be required, what tow configuration is best for navigation, and what are the costs involved in the various alternate configurations?	

ORDPD-F

CHANDLER
10 Nov 70

Inefficiencies in Inland Waterways Operations

Inefficiencies can be defined (a) as failure to take advantage of opportunities, (b) as unnecessary input effort required to obtain the output received, or (c) as wasteful actions.

Knowledge is the prime requisite for reduction of inefficiencies. Until an opportunity is noticed, input effort is evaluated or waste is recognized there is no reason for change. Effort is the second requisite. Effort is required to obtain and distribute knowledge, and inefficiencies in waterway use can not be reduced without effort.

Consideration has been given to various kinds of inefficiencies, the possibilities for doing the work required to get and distribute the knowledge needed to attack them, and the possible national gain from expending the effort required.

The waterways are one of many modes of transportation, and transportation is but one of the factors in national resource utilization. Large areas of opportunities, input effort, and waste are outside of the waterway system, and have been left for later consideration.

As a basis for study, it is held that almost all large inefficiencies within the inland waterway system have been eliminated. Remaining inefficiencies are relatively small, hard to understand, and difficult to cure. The waterway system has been under construction and in use for over 130 years, is carrying 15% of the nation's traffic and is composed of and operated by many diverse interests who all have been looking for opportunities, profits and waste. Within the waterway operator's industry profitable ideas spread rapidly and major equipment changes, such as the shift to the Kortnozzle or larger towboats, occured in a few years. Federal waterway operations and maintenance problems have been solved at many places, and the solutions used subsequently, or the problem designed out of later projects. There are many inefficiencies where the cure is known and justified, ~~[illegible]~~ but lack of time and money prevent action.

There is a whole class of inefficiencies in the inland waterway system that result from separate ownership of all or parts of the resource, the waterway and the equipment involved. Large quantities of coal, oil, chemicals, pass identical items shipped in the opposite directions by different owners. Terminal, towboat, and barge utilization have similar inefficiencies for the same reason.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONLUSIONS AND/OR EVALUATION
Bow Steerers	Note from George B. Davis, LMVED to LTC F. M. Anklam, WES, 14 OCT 70	The addition of steering units such as "Harbor Masters" to the front ends of long tows would materially improve their operation.	

210 North Twelfth Street
St. Louis, Missouri 63101
26 October 1970

F. M. Anklam
LTC, CE
Deputy Director
Waterway Experiment Station
Vicksburg, Mississippi 39180

Dear Colonel Anklam:

Inclosed are responses to your request in letter dated 24 September 1970, subject: Inefficiencies and Potential Nonstructural Improvements in Inland Waterways Operations.

Our Operations Division has enumerated five nonstructural improvements while our Design Branch has enumerated what may be considered to be minor structural improvements.

If we may be of further assistance in helping you accomplish your task, feel free to phone Messrs. Burke or Eickhorst at 314-268-3385.

Anson G. Eickhorst

1 Incl
As stated

ANSON G. EICKHORST
Member, Inland Waterway
Simulation Task Group

Roger A. Burke

ROGER A. BURKE
Member, Inland Waterway
Simulation Task Group

Item	Description	Discussion	Conclusion and/or Evaluation
Travelling Kevels	Mooring post on wheels that are controlled by winches and connecting cables	Lockage time can be reduced using travelling kevels to guide the tows in the lock and pull the first cut of a double tow out of the lock. Time is saved and safety improved by positive stopping action of travelling kevels.	Details of this are continued in a letter report from SLD to LMVD, subject: Traveling Kevels for Locks Nos. 24 and 25, dated 19 December 1969
Equipment Improvements for Towing Industry	Bow thruster units on front barges.	The bow thruster on the front of a tow would give the pilot much more control over the tow than presently is the case. This would allow the pilot or lead deck hand to control the bow of the tow and result in shorter lock approach time.	Bow thrusters are used on tows in the St. Lawrence Seaway with success. They are not presently used on tows in the Upper Mississippi River.
Small Lock for Pleasure Craft	30 feet by 100 feet lock designed to pass pleasure boats	The small pleasure boat lock is being seriously considered for the New Lock No. 26 project. Preliminary studies show that the cost of the small lock is more than justified by the increase in commercial lock capacity it generates.	Studies are underway on New Lock 26 to install a small boat lock on the opposite side of the river from the two main commercial locks.

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
906 OLIVE STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

LMSOD-NL

7 October 1970

SUBJECT: Potential Nonstructural Improvements in Inland Waterways Operations

Division Engineer, Lower Mississippi Valley
ATTN: LMVCO-O

Information requested in multiple letter of 30 September 1970 regarding above subject is attached.

FOR THE DISTRICT ENGINEER:

Incl
as

JAMES A. PETERSEN
Acting Chief, Operations Division

ITEM	DESCRIPTION	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
1. Traffic control at locks.	At Locks 26, Alton, Illinois, a rule of "three up and three down" has been applied whenever three or more vessels are awaiting lockage in either direction.	Allowing the second and third vessels, traveling in the same direction, to make their approach while the previous vessel is locking saves a considerable amount of time during each cycle. It is estimated one hour is saved per cycle.	System works fine and industry is happy with this system. Also extremely beneficial during ice periods in that a minimal amount of ice is pushed into the chamber.
2. Switchboat assistance.	At Locks 26, Alton, Illinois, a test of using a switchboat to measure increased lockage capacity is being run during the month of October 1970. In conjunction with this, mooring barges have been placed upstream and downstream to be used for specific double lockages.	Switchboat is being used as follows: For 1st and 2nd tows of three down cycle to pull 1st cut of double lockages out of lock and tie on lower guidewall. For 3rd tow of three down cycle to pull 1st cut of double out of lock and tie to downstream mooring barge. For all three tows upbound in three up cycle pull 1st cut of double lockages out of lock and tie to upstream mooring barge. For tows which can traverse the lock in a single lockage by "knocking the boat out" the switchboat assists in this process.	Test period is still very short but as of 7 October 1970 at 8 am the following results have been noted: 175 vessels have used the facility to date this month with 1,120,550 tons of commodities. Only one morning to date at 8 am were any vessels backlogged awaiting lockage. On 6 October 1970 three vessels were awaiting lockage. System thus has been working better than hoped for and each double lockage has been made in a minimum of half an hour quicker than with the tow haulage unit.

ITEM	DESCRIPTION	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
3. Split-tow assistance.	At Locks 24 and 25 this is used. A winch with a long cable pulls the first half of a double lockage out of the lock.	This arrangement avoids requiring tows with double lockages to "double trip" the lock. That is, prevents the necessity for the towboat to recycle to pick up his barges.	This has worked well in the past, would become obsolete if switchboats were used at all locks.
4. Staffing improvements.	Generally speaking, all of the locks within this District are operating with the same staffing pattern as they did ten years *ago. At Locks 26 additional* lockmen positions were established but not filled so that we can have two lockmen per shift per lock.	A clerk-typist position has been added at Locks 26 and 27. This frees the lockmaster from most menial repetitive tasks. Similar positions have been established at Locks 24 and 25 but manpower spaces have not been available to fill these positions. *Presently, at Locks 26 one* lockman operates the auxiliary lock and is responsible for setting 33 dam gates. Four additional positions are urgently needed *for efficient* operations.	The clerk adds greatly to the overall lock efficiency. Lock operating personnel can concentrate on locking vessels, regulating pools, etc. This should not be a position established on basis of tonnage but rather on amounts of daily and monthly forms, correspondence, telephone calls, etc. Two lock and dam operators per lock are a recommended minimum for *safe efficient operation.*

ITEM	DESCRIPTION	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
5. Bad weather modifications.	At all locks within this District during the severest ice conditions we restrict the tow width to one or two barges wide.	During severe ice periods when ice accumulates on the miter gates or in the miter gate recesses, we cannot fully open the gates. To prevent structural damage to the miter gates we restrict the tows to one or two wide. This allows us to lock vessels with a safety factor during severe ice conditions.	This is not ideal but does enable us to remain in operation during periods of heavy river ice. This normally would not last for more than one month of each year.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Inefficiencies and Nonstructural Improvements	Note from Raymond H. Haas, LMVED to LTC F. M. Anklam, WES, 13 Oct 70	Channel Improvement Branch has no information pertaining to inefficiencies and nonstructural improvements that would be useful to LTC Anklam.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
a. Hazardous conditions	Hazardous entrance condition reported at lock on southern waterway.	Hazardous lock entrance condition reported. Since no complaints from navigation interests, condition not passed on so as to avoid advertisement of system weakness. Notes periodic meetings held with reps. of navigation interests to hear complaints. Also, Corps personnel make trips on tows to observe currents in critical reaches.	
b. Lock Approaches	Dike constructed at an upstream lock entrance to improve navigation. Memo from J. J. Franco, WESHR to LTC F. M. Anklam, WES, 30 Oct 70	Lock navigation improved by construction of upstream dike 325 ft long, later extended to 500 ft. Drift obstructing lock filling ports so it is planned to extend dike another 100 ft. Not known whether lock approach depth affected by shoaling below dike.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
c. Locking Delays	Wind causing lock entrance delays. Memo from J.J. Franco, WESHR to LTC F. M. Anklam, WES, 30 Oct 70	Effect of wind on tows observed and filmed. Wind causing considerable delay of barges moving into and through canal; effect particularly serious on empty barges. Notes possibility of providing hydraulic assistance if lock exit time is a problem.	

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
668 FEDERAL BUILDING
MEMPHIS, TENNESSEE 38103

S - 9 October 1970

IN REPLY REFER TO LMMOD-NN

6 October 1970

SUBJECT: Potential Nonstructural Improvements in Inland Waterways Operations

Division Engineer, Lower Mississippi Valley
ATTN: LMVCO-O

1. Reference: Multiple letter LMVCO-O, subject as above, dated 30 September 1970.

2. Information on nonstructural items for improvement of waterways transportation system within the District is not available.

FOR THE DISTRICT ENGINEER:

H G Hurley
H. G. HURLEY
Chief, Operations Division

DEPARTMENT OF THE ARMY
VICKSBURG DISTRICT, CORPS OF ENGINEERS
VICKSBURG, MISSISSIPPI 39180

LMKOD-NP

7 October 1970

SUBJECT: Potential Nonstructural Improvements in Inland Waterways Operations

Division Engineer, Lower Mississippi Valley
ATTN: LMVCO-O

1. Reference is made to your multiple letter of 30 September 1970, subject as above, requesting information for reply to Civil Works Task Group questionnaire.

2. The Vicksburg District is now constructing new modern locks and dams on the Ouachita-Black Rivers to replace the existing six antiquated structures. The operation, traffic control, and the handling of pleasure craft at the existing structures have posed no particular problem. Consequently, our comments must be of a general nature or restricted to observations at facilities located outside of the Vicksburg District.

3. The information we have on the subject matter is furnished on the inclosure which has been prepared in accordance with the suggested format.

FOR THE DISTRICT ENGINEER:

1 Incl
as

HUGH P. JOHNSON
MAJ, CE
Deputy District Engineer

Potential Nonstructural Improvements in Inland Waterways Operations

ITEM	DESCRIPTION	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
a. Procedural Changes		No comment	
b. Staffing improvements	Locks and Dams	Locks should be staffed with sufficient personnel to operate without assistance from boat crew.	Inexperienced personnel from boat crew at times assist in locking vessels thru locks. This requires additional time to make lockage and presents a potential hazard to safety of vessels and structure.
c. Traffic controls		We have had no problem with traffic control at locks.	
d. Change in lock operation	Locks and Dams	Locks should be operated on 24 hour basis.	Restricted navigation will normally reduce commodity movements on waterway.
e. Scheduling of tows according to size, maneuverability, etc.	Locks and Dams	Any change in order of lockage from first arrival will not be received favorably.	
f. Improved utilization of barges and/or towboats		Navigation interests have done much study to better utilize equipment.	Progress has been made in use of towing vessels.
g. Provide tugs or other assistance to units too large for one lockage		Assistance in moving barges thru locks will reduce traffic build-up.	Private harbor boat service at expense of industry will speed up lockage.
h. Bad weather modifications	Locks	In instances, vessels have entered locks by radar.	This procedure appears to be hazardous to tow and facility.

Sheet 1 of 2

ITEM	DESCRIPTION	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
i. Equipment improvement for towing industry		Consideration might be given to installing winches on barge to replace ratchets.	
j. Port developments and changes		Port development and changes are normally made to keep abreast of traffic increase	
k. Handling of pleasure craft		At busy locks, consideration might be given to passing small pleasure boats by methods other than locking.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Hydraulic Operation	Lock on Ohio River. Comments of T. E. Murphy, WESHS to LTC F. M. Anklam, WESVR, conf. of 20 Nov 70	Particular lock had been cited as one in which valve operation and operating procedures were well coordinated. Upon inspection, it was found that one valve was operating <u>twice</u> as fast as the other valve; this occurring at a lock where proper valve syncronization was very important. Improper valve syncronization could cause severe hawser stresses and surges with possible resultant damage to barges and lock gates.	Example of lock not being operated according to design procedure and failure to have projected changes reviewed by hydraulic engineers.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Hydraulic Operation	Lock between southern waterways. Comments of T. E. Murphy, WESHS, to LTC F. M. Anklam, WESVR, conf. of 20 Nov 70	Because of an accident and subsequent closure of an upstream structure, head differential at the lock reached a level of 35 ft. which exceeded the maximum design head differential. At this time, it was found that the lock operator was operating the valves in 2 minutes which was less than the 2.5 minute minimum design operating time recommended for minimum head differentials.	Better coordination between lock designers and operators is needed. More severe design conditions may be needed and designers should strive to make designs as insensitive as possible to effects of improper operating procedures.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Hydraulic Operation	Lock on Warrior River. Comments of T. E. Murphy, WESHS to LTC F. M. Anklam, WESVR, conf. of 20 Nov 70	At lock in question, valves were to be operated in 4 minutes but were never properly adjusted to operate at that rate nor were operating personnel notified of proper procedures. As a result, the valves were being operated in 1-1/2 minutes. operating personnel found that operating valves full open caused too much turbulence in the lock chamber and therefore limited valve opening to 75%. This setting was such however as to cause severe hydraulic conditions within the lock culvert/hydraulic system and could have severely damaged lock hardware.	Lock valves never properly adjusted and operating personnel not advised of intended operating procedures.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Hydraulic Operation	Lock on western river: Comments of T. E. Murphy, WESHS to LTC F. M. Anklam, WESVR, conf. of 20 Nov 70	Lock valves had been designed for 4 minute operating time but operator found that severe disturbances occurred at that rate and increased valve time to 15 minutes; lock filling time was increased by 5 min. During inspection, condition was noted and it was found that District personnel were unaware of the problem and could therefore offer no ready explanation.	Locks may not always operate as intended and designers may not learn of problem for some time. Operators must be made aware of need for reporting operating difficulties so that they may be quickly aleviated.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Locking Procedures	Comments of T. E. Murphy, WESHS to LTC F. M. Anklam, WESVR, conf. of 20 Nov 70	Improvements in lock operation should be made. Automatic valve operation has been successfully used in Canada and could greatly improve operations at U.S. locks. Locks using manual valve operation are rarely operated according to design procedures, resulting in slow operation and possible damage to locks and vessels. Study should be given to ways of improving passing conditions in lock approaches so that efficient "one up/one down" operating rules could be used.	Within the first year of operation of new locks, operational inspections should be made to insure that the locks are being operated according to design procedures. This would supplement the currently required structural inpections and reports for new locks.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock discharge hazard	Restriction of boating (for fishing) in stilling basin and lock discharge areas varies among locks. Memo from E. B. Pickett, WESHP to LTC F. M. Anklam, WESVR, 12 Oct 70	Outflow from locks usually is very turbulent and hazardous to small boats. Operators often must wait for small boats to clear area before discharging. Suggest uniform restriction of boats from potentially dangerous areas with uniform marking, floating markers, etc.	Believe boaters and fishermen will stay clear of dangerous areas (though reluctantly) if rules are fair and enforced.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Tourist control at locks	Greatly varies - from special fenced areas (Soo) to unlimited access at many. Memo from E. B. Pickett, WESHP to LTC F. M. Anklam, WESVR, 12 Oct 70	Many locks often have only one attendant. Free access of public on decks and miter gates requires extra precaution by operator, and still leaves hazards: smoking during transit of flamable cargoes, danger to small children climbing on rail to see better (including parents seating them on top bits on lock side of railing!), and possible tampering with equipment (valves, controls, etc.).	Public likes to see and is generally entitled to do so. Good public relations. However, believe most will accept viewing from a well located, restricted vantage point.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Hydraulic operation of Locks	Lock operators are often unaware of consequences of their changes in methods of operation of the filling and emptying systems. Memo from E. B. Pickett, WESHP to LTC F. M. Anklam, WESVR, 12 Oct 70	The method of operation (valve schedule) of a lock is an important factor in the lock design to insure rapid filling, minimum hawser stress and turbulence, and minimum cavitation and valve vibration. Many locks are operated without knowledge of what conditions exist within the hydraulic system. Only "idiot lights" show the valve position. Valves sometimes stall or are operated at the wrong speeds. Each lock should be checked periodically (annually?) with minimal measurements of valve speed, sound levels, filling rate, oil pressures, etc. for conformity with design or other specified operating procedures.	Adjustment of operation to desirable procedure and education of operators on problems from variations of procedure should protect lock from damage and ensure most efficient operation. Necessary changes in operation can be evaluated and adapted.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Pleasure craft lockage	Varies among locks. Increasing numbers of novice boaters. Memo from E. B. Pickett, WESHP to LTC F. M. Anklam, WESVR, 12 Oct 70	Suggest signs in approaches telling important factors relative to small craft at that lock: locations in lock to use or avoid, tie to floating bit (not ladder!), observe signals, etc. Also suggest operation on fixed schedule where operation is primarily for pleasure craft.	Believe most boaters glad to cooperate in expediting passage.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C. 20315

IN REPLY REFER TO

ENGBR

21 October 1970

LTC Frederick M. Anklam, Deputy Director
USA Engineer Waterways Experiment Station
Vicksburg, Mississippi 39180

Dear Colonel Anklam:

You will find inclosed a list of nonstructural improvements that might be investigated to increase efficiency in inland waterway operations.

I hope these will be of use in your assignment. Nonstructural improvements may prove to be the least costly way to increase waterway utility.

Sincerely yours,

Dick

RICHARD G. WAUGH, JR.

1 Incl
as

NON-STRUCTURAL IMPROVEMENTS
IN INLAND WATERWAY OPERATIONS

20 October 1970

ITEM 1 - Speed limit regulation

Description - On certain sections of the inland waterways, speed limits are set to control the speed of tows.

Discussion - Many times speed limits deter the operation of tows. For example, it is known that weekend speed limits in the Cincinnati section of the Ohio River are set to keep tow speeds down so that they do not upset the numerous pleasure craft on the river. In other cases, it seems that speed limits have been set rather arbitrarily without due consideration of the effects on towing economy.

Conclusions - Review all waterway speed limits to optimize waterway operations.

ITEM 2 - Pilot licensing

Description - Present tow licensing is almost non-existent.

Discussion - Some tows are union; some are non-union. Efficiency of operation varies with the skill of the towboat pilots and crews. While some pilots are good on rivers, they may be poor in locking tows. On certain reaches of particular waterways, it pays to have experienced pilots operating. This is why some large operators "turn tows"; they let their pilots operate continuously in familiar stretches of waterways.

Conclusions - Consider licensing pilots and crews for all tows in all sections of the waterways. Consider having master pilots for certain difficult locks or waterways, similar to present piloting practices for major ports. This is now done on the Danube River.

ITEM 3 - Modify obstructions.

Description - Many bridges, wharves, and other structures presently restrict tow operations.

Discussion - At the north approach to Lock 26, entering the lock can be quite difficult when barges are moored at terminals on the approach. On various waterways, bridges that restrict tow movement might be modified at relatively little expense.

Conclusions - Review all present obstacles to tow movements on the waterways and at locks, and consider removal or relocation of these to improve tow and lock efficiency.

Non-Structural Improvements in Inland Waterway Operations -

ITEM 4 - Radar and radio control

Description - Use of electronic equipment by tow operators is sporadic.

Discussion - Some tow operators have established pretty good communications with their tow pilots. Communication between pilots and lockmasters (other than the time spent at the locks) is less than desirable for efficient waterway operations. Some pilots use radar for operation during night hours and fog; others do not attempt movement on certain waterways except during daylight hours.

Conclusions - Review waterway communications between tow pilots and lockmasters to see if it is not possible to operate the waterways and locks as a system to reduce bottlenecks. Endorse greater use of radar equipment for better utilization of available navigation periods.

ITEM 5 - Navigation aids

Description - Tow speeds are sometimes restricted by lack of adequate navigation aids through difficult reaches.

Conclusions - Review navigation aids program to see if added buoys, range lights, etc., cannot improve tow speeds.

ITEM 6 - Bow thrusters (or bow steerers)

Description - Steering devices mounted at the head barge of a tow can increase tow speeds through tortuous reaches.

Conclusions - Investigate bow steering devices and consider an education program to encourage industry use of such.

ITEM 7 - Lock operating procedures

Description - At certain locks, it may be found that the "3 up - 3 down," "4 up - 4 down," or "5 up - 5 down" are preferable to alternate up and down lockages. Also, limiting double lockages can increase locking efficiency.

Discussion - At the Industrial Lock, it has been found that "4 up - 4 down" and variations can speed up locking operations when queues develop. Other locks have instituted similar practices. Also at the Industrial Lock, an operating procedure calls for tows requiring double lockages to go to the end of the line with the second part of the tow when queues exist. This has been successful in that most operators prefer to hire a trip boat to bring their tows through rather than suffer the time penalty.

<u>ITEM 7</u> - Lock operating procedures (continued)

<u>Conclusions</u> - Institute "3 up - 3 down" or similar arrangements at all locks where capacity can be increased in this manner. Also, immedicately enforce a double-lockage procedure that requires an "end-of-the-line" for those tows.

<u>ITEM 8</u> - Awards for good performance and fines

<u>Description</u> - The towing industry should be encouraged to perform at maximum efficiency.

<u>Discussion</u> - The Corps of Engineers at its locks and the Coast Guard on the waterways should enforce efficient tow movements.

<u>Conclusions</u> - Institute a system of performance awards and penalties for tow operators.

<u>ITEM 9</u> - Supervisory inspection team

<u>Description</u> - Quite often, practices already instituted on waterways in one section of the country have not yet come to the attention of operating personnel in other areas.

<u>Conclusions</u> - To encourage use of the waterways as a system, an OCE inspection team--with authority to institute better operating procedures--should be created to conduct surprise visits to waterways and locks and review practices for operating the system.

<u>ITEM 10</u> - Committee on Inland Waterways

<u>Conclusions</u> - The Corps of Engineers should create a Committee on Inland Waterways to bring together planning, engineering, construction, and operating personnel to encourage dialogue between staff to increase efficient operation of the waterways system.

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APPENDIX F: EXTRACTS FROM REFERENCES

ITEMS	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Current European practices in inland water transport	De Beaufort, W.F.A. Report to the XXIInd International Navigation Congress, Paris, 1969, Section 1, Subject 1, p.221-227.	General discussion of conveyance systems used on European waterways (particularly the Rhine) and which further developments may be expected.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Inland water transport in the USSR and Hungary	United Nations. Inland Water Transport in the Union of Soviet Socialist Republics and Hungary; Report of the Study Group of Experts from Asia and the Far East on their visits to USSR and Hungary, August to October 1959. New York, 1961.	Observations of the tour group in the USSR and Hungary included: transport craft description, economic aspects of inland waterways transport, cargo handling, construction and maintenance of vessels, river conservancy and dredging, and navigation structures.	Part Three of report gives Recommendations (i.e., Applicability of notable features observed) from representatives of Burma, India, Indonesia, Japan, Pakistan as they would apply to each one's own country. Report contains 69 figures; some are photographs giving such details as quick-release hooks on connecting hawer and floating bollards.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Barge transportation on Columbia River	Torget, W.E., and Funston, R. Innovations in Barge Transportation on Columbia River. ASCE Proceedings, vol.96, Journal of the Waterways and Harbors Division, No.WW2, p.411-432, May 1970; Paper 7290.	Barge traffic on the Columbia River is dissimilar in many respects to that of the typical inland waterway. The average haul is short, less than 300 miles. Resources, population, and industrial activity of the tributary area restrict the volume and diversity of traffic. Effective utilization of barge transportation under these limitations has led to some significant innovations, both in equipment and terminal facilities developed to serve the traffic requirements of this particular economy. Several forest products plants move almost their entire output by water.	There is a unique terminal and distribution facility in Portland, Oregon, which provides an interchange between barge and other transportation media. The combination barge, capable of carrying a variety of commodities, was developed to better serve the needs of the upriver agricultural economy. Also in this category is the large ocean-river barge, the Kenai, which transports fertilizer materials from Alaska to the mid-Columbia area.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Panama Canal Improvement	Kearney (A.T.) and Co., Management Consultants. Improvement Program for the Panama Canal; Report. Chicago, Ill., 100 South Wacker Drive, 1969.	Report of study made in order to provide a sequential program of capital improvement for the Panama Canal which will increase the capacity of the Canal in phase with increasing traffic. Secondary objective is to identify factors that limit capacity and to determine capacity of the Canal after completion of suggested improvements. Report gives factors affecting canal capacity, computer simulation studies, evaluation of capital improvement projects, and improvement program.	Summary of project recommendations (copy of p.V-48 from report) is appended.

PANAMA CANAL COMPANY
SUMMARY OF PROJECT RECOMMENDATIONS

Project Number	Project Description	Recommendations: Implement As Soon As Practical	Do Not Implement	Determine Timing of Implementation	Comments
1-L-69	Purchase Additional Locomotives and Component Parts			X	3 purchases of 6, 20 and 20 locomotives
2-L-69	Modify Locks Machinery Control System			X	
3-L-69	Increase Speed of Locks Machinery		X		Evaluate faster speeds and changing speed without stopping before ordering new locomotives
4-L-69	Improve Hydraulics of Center Culverts		X		
5-L-69	Construct a Fourth Culvert at Locks		X		
6-L-69	Install Valves In Lock Gates			X	Install only in gates where lockage interval will be reduced
7-L-69	Relocate Upper Chain Fenders-Gatun	X			Change location only if procedures cannot be safely modified
8-L-69	Improve Method of Changing Locomotives in Relay Lockages		X		Improved method necessary but this scheme is too costly
9-L-69	Modify Track Alignment at "S" Curves-Gatun	X			
10-L-69	Augment Switching and Parking Facilities for Locomotives		X		Included in Project 14-L-69
11-L-69	Install Lateral Culvert Bulkheads, Miraflores	X			
12-L-69	Install Lateral Culvert Bulkheads, Gatun		X		No economic benefit
13-L-69	Improve Bulkheads and Seats for Main Culvert Intakes and Discharges	X			
14-L-69	Use Merry-Go-Round Procedures in Lieu of Relays			X	Provide capacity beyond that possible with relays
1-N-69	Provide Navigational Capability For Transiting Vessels During Periods of Restricted Visibility	X			Research to determine the feasibility of fog control or dissipation should also be continued.
2-N-69	Provide Additional Tugs			X	Necessary to assist transit operations
3-N-69	Widen Pacific Sea Approach, Balboa and Miraflores Reaches to Miraflores Locks			X	Widen only Balboa and Miraflores reaches
4-N-69	Widen Atlantic Entrance Channel, Bouy 6 to Gatun Locks			X	Widen only from Bouy 13 to Gatun Locks, do not widen from Bouy 6 to Bouy 13.
5-N-69	Modernize Marine Traffic Control Systems	X			Necessary for Canal to achieve its potential capacity
6-N-69	Construct Tie-Up Station North of Pedro Miguel Locks		X		Reevaluate if fog prevention or dissipation proves impractical
7-N-69	Extend Cristobal Anchorage		X		Assign ships to locations according to draft, not a capacity item.
8-N-69	Extend Gatun Anchorage		X		Not a capacity item but may be justified for improved safety.
1,2 & 3-W-69	Water Supply Projects			X	Deepen to 37' PLD while pumping is being studied and further evaluated

7-N-69	Extend Cristobal Anchorage	x		proves impractical
8-N-69	Extend Gatun Anchorage	x		Assign ships to locations according to draft, not a capacity item.
1,2 & 3-W-69	Water Supply Projects	x		Not a capacity item but may be justified for improved safety.
			x	Deepen to 37' PLD while pumping is being studied and further evaluated

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Barge lift	For 1350 Ton Barges: a Speedy Lift, Engineering, vol.204, p.58-60, 14 July 1967.	The Ronquières Incline barge lift in Southern Belgium replaces 28 locks and a tortuous section of the Charleroi-Brussels Canal. It can raise or lower two 1350-ton barges through a 68m lift in a little over 20 minutes. Incline consists of a pair of ribbons of reinforced concrete, 1431m long, carrying four sets of rail tracks apiece on a 5% gradient. The traveling tanks that convey the vessels between the upper and lower levels are 91m long and run on 236 wheels.	This type lift was chosen over a hydraulic barge lift. The terrain at Ronquières lends itself well to an incline. It is expected to reduce journey time from one end of canal to the other from about 35 hours to about 10.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Port location	Petersen, J.F. Planning of Ports. PIANC Bulletin, vol. 1/2, no.1, p.87-93, 1968-1969.	In this article "port" means commercial ports, fishing ports, and ferry boat harbors. Deals with existing port improvements and planning new ports. Factors to be considered in planning are listed.	Port should not be located adjacent to a city or town unless absolutely necessary. Abundant area and convenient traffic line connections are of vital importance.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Location	Bottoms, E. E. "Economic Location of Locks," PIANC vol. III-IV, 68-69, p 45. also <u>Transportation Engineering Journal</u>, ASCE, Vol. 95, No. TE1, Proc. Paper 6397, Feb. 69, pp. 77-96.	User benefits should be major consideration in lock site selection. Discusses effects of river depth and bends, horsepower, and channel width on towing costs. discusses effects of tow size, guard walls, bow steerers, lock location, tow couplings, and tow standardization on lock entry/exit times. Discusses lock location from standpoint of flow and sedimentation and points out need for careful study in lock location.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Location	"Economic Location of Locks," Discussion by Chandler, Alan R., Transportation Engineering Journal, ASCE, Vol. 95, No. TE4, Proc. Paper 6868, Nov. 69, p. 700.	Emphasizes that while tow industry needs may have been carefully considered at time of lock design, changes in tow configurations have made locks inadequate. Inadequate design predictions are to blame. Notes that industry needs are not necessarily the paramount consideration.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Location	"Economic Location of Locks," discussion by Franco, John J., Transportation Engineering Journal, ASCE, Vol. 95, No. TE4, Proc. Paper 6868, Nov. 69, pp. 700-703.	Reemphasizes "'the needs of the customer are paramount and deserve first consideration.'" Points out that necessary data for best lock location may not be available or analysis may not be practical. Notes value of model studies.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Location	"Economic Location of Locks," Discussion by Vogel, Herbert D., Transportation Engineering Journal, ASCE, Vol. 95, No. TE4, Proc. Paper 6868, Nov. 69, p. 704.	Stresses importance of model studies in selection of lock location and size. Points out importance of proper lock size choice to minimize waste of water and energy.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Location	"Economic Location of Locks," Discussion by Gaum, Carl H., *Transportation Engineering Journal*, ASCE, Vol, 96, No. TE1, Proc. Paper 7048, Feb. 70, p. 117.	Comments on effect of inadequate design predictions but notes that tow boat technology and tow traffic have increased rapidly. Suggests systems concept for improvements and notes that environmental factors will become an important planning consideration.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Location	"Economic Location of Locks," Discussion by Lang, Edmund H., Transportation Engineering Journal, ASCE, Vol. 96, No. TE1, Proc. Paper 7048, Feb. 70, p. 119.	Suggests that lock locations may have been based more on judgment than on careful analysis in the past. Notes that future planning on the part of tow operators is generally poor or nonexistent. Points out importance of proper lock size.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Location	"Economic Location of Locks," Discussion by Davis, John P., Transportation Engineering Journal, ASCE, Vol. 96, No. TE1, Proc. Paper 7048, Feb. 70, p. 121.	Comments that lock construction costs should be minimized but points out that construction savings are lost if the structure is not properly serviceable to the towing industry. Suggests particular care in effecting those low cost design alterations which will improve structure's operating efficiency.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Capacity	"Tonnage Capacity of Locks," Davis, John P., Journal of the Waterways and Harbors Division, ASCE, Vol. 95, WW2, Proc. Paper 6577, May 69, pp. 201-213.	Points out that planning and design studies for new facilities must consider the tonnage capacity of existing and other planned facilities. Notes that a planning period must be selected for the project but may be rather arbitrary. Lists capacity factors as: Lock size, transit time, commodity characteristics, tow characteristics, operation interruptions, adjacent locks, pleasure craft, and tow operator profit margin. Presents methodical computations for estimating expected capacity but concedes fairly wide variation possible due to judgment factors.	Capacity determination method may be adequate for some purposes or may be used in development of more sophisticated methods.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Capacity	"Tonnage Capacity of Locks," Discussions, Journal of the Waterways and Harbors Division, ASCE.		
	Vol. 95:		
	Chandler, Alan R., WW4, Proc. Paper 6869, Nov. 69, p. 602.	Chandler notes that lock capacity is often a time varying factor.	
	Vol. 96:		
	Bottoms, E. E., WW1, Proc. Paper 7049, Feb. 70, pp. 161-164.	Bottoms questions reliability of Davis' data.	
	Davis, John P., WW3, Proc. Paper 7443, Aug. 70, pp. 729-731.	Davis comments on traffic control as related to Chandler's discussion and discusses further the questions of data raised by Bottoms.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Size	"Problems of Inland Waterway Lock Dimensions," Journal of the Waterways and Harbors Division, ASCE, Vol. 96, No. WW2, Proc. Paper 7295, Davis, John P., May 70, pp. 451-466.	Notes problems of determining proper lock sizes and desirability of having lock size consistent throughout a waterway. Mentions that present lock size standards were developed in 1950's by Bloor. Points out that locking time increases when tow clearance decreases and that double lockages take more than twice as long as single lockages. Recommends: Max. tow size limitations, new lock size standards (with tables), standard lock sizes for restricted channels, minimum lock depths, equipment for reducing lockage times such as winches and traveling kevels, and increased lock personnel and tug assistance as needed.	Davis discusses many of the important factors in lock size determination.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Size	"Problems of Inland Waterway Lock Dimensions," Discussion by Barker, Bruce and Gerald D. Seinwill, Journal of the Waterways and Harbors Division, ASCE, Vol. 96, No. WW4, Proc. paper 7645, Nov. 70, pp. 874-875.	Barker and Seinwill claim that Davis' suggested lock sizes are much too small and thus are ultimately uneconomical.	Comment may be appropriate but does not appear to adequately consider the overall systems consideration.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Duplicate locks	Santina, W.J., and Wesler, G.B. Duplicate Locks for Illinois Waterway. ASCE Proceedings, vol.90, Journal of the Waterways and Harbors Division, No.WW4, p.1-26, Nov. 1964; Paper 4118.	Results of a study by the Corps of Engineers indicating the advisability of providing duplicate locks along the Illinois Waterway are presented. The waterway provides the only water connection between the Mississippi River-Ohio River navigation system and the Great Lakes. It is completely canalized, i.e., it consists of a series of pools created by a system of locks and dams. An analysis of future electric power requirements and coal consumption, trends in population and gross national product, and other information indicated that prospective commerce on the waterway below Lockport will reach 32,700,000 tons by the year 1970 and 55,000,000 tons by 2020. Statistics on lock operation, annual commerce through each lock and on the waterway were used in determining capacities of the existing single locks.	Comparison of the waterway capacity as limited by the existing single locks with the estimated prospective commerce indicated that economical transportation of waterborne commerce will not be possible without provision of an additional lock at each existing lock site. Times of construction of the various additional locks were determined when the capacity of each existing lock would be reached.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Reduction of transit times of downbound vessels	Windsor, J.S. Hydraulic Assistance on the Welland Ship Canal. ASCE Proceedings, vol.94, Journal of the Waterways and Harbors Division, no.WW1, p.1-10, Feb. 1968; Paper 5770.	Field studies at Lock No.8 on the Welland Ship Canal show the effectiveness of hydraulic assistance in reducing the transit times of downbound vessels. A ship travelling in a restricted channel, such as a lock, displaces water in a direction opposite to ship movement; this reverse flow is accompanied by a drop in water level along the ship's hull. The ship will squat or settle in the water, therefore retarding its progress.	The introduction of water at the upstream end of the lock reduces the back flow velocities and produces an increase in ship velocity thus reducing transit times.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Hydraulic Operation	"Filling system for Lower Granite Lock," Richardson, George C., _Journal of the Waterways and Harbors Divsion,_ ASCE, Vol. 95, No. WW3, Proc. Paper 6718, Aug. 69, pp. 275-289.	Describes bottom longitudinal filling system at Lower Granite which permits faster lockage, reduced hawser stress, and greater safety of operation.	System may find wide applicability in increasing efficiency of future lock installations.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Hydraulic Operation	"Surge Problems in Canals with High-Lift Locks," Liddell, Donald M., *Journal of the Waterways and Harbors Division,* ASCE, Vol. 95, No. WW4, Proc. Paper 6898, Nov. 69, pp. 467-490.	Discusses surge problems associated with high lift locks especially with respect to the planned Lake Erie-Lake Ontario waterway. Comments on importance of water usage and lift height. Discusses surge problems in the Welland canal, the Soo, and at McAlpine Lock on the Ohio River. Evaluates various surge control methods and describes proposed system for LEO waterway.	Applies to several of the problems related to lift height trade-offs.

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ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Hydraulic Operation	"Surge Problems in Canals with High-Lift Locks," Discussions, Journal of the Waterways and Harbors Division, ASCE. Vol. 96: No WW2, Proc. Paper 7252, May 70. Soucek, Edward, pp. 579-580. Windsor, James F., p. 581. No. WW3, Proc. Paper 7443, Aug. 70, Saarits, Raymond, pp. 751-754. No. WW4, Proc. Paper 7645, Nov. 70, McNown, John S., pp. 861-863.	Discussions present alternative surge control techniques and discuss problems experienced at several other installations.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Hydraulic Operation	"Computer Model for a Lock Manifold System," Windsor, James S., Journal of the Waterways and Harbors Division, ASCE, Vol. 95, No. WW2, Proc. Paper 6553, May 69, pp. 149-162.	Computer program solves unsteady flow equations for a twenty port lock manifold and can be used to determine lock filling times and flow distribution for any operating procedure.	Program might be useful in determining optimum lock operating procedure at existing facilities.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Lock Hydraulic Operation	"Computer Model for a Lock Manifold System," Discussions, Journal of the Waterways and Harbors Division, ASCE,	Discussions consider various methods for solving the differential equations.	
	Vol. 96:		
	Wiggert, David C., No. WW1, Proc. Paper 7049, Feb. 70, pp. 158-159		
	Windsor, J. S. and Herman Vallee, No. WW3, Proc. Paper 7443, Aug. 70, pp. 728-729.		

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Projected plan for Ohio Basin navigation	Kent, T.A. Framework Plan for Ohio Basin Navigation to 2020. ASCE Proceedings, vol.96, Journal of the Waterways, Harbors, and Coastal Engineering Division, No.WW3, p.665-687, Aug. 1970; Paper 7473.	By 2020, the need for transporting cargo on Ohio Region waterways will reach nearly 150 billion ton-miles, five times the region's 1965 waterborne traffic. To meet future needs a framework plan and development program is formulated as a broad guide to the best use of navigation resources. Demand for navigation on the existing system is estimated for 1980, 2000, 2020, based generally on indices of projected industrial and household demand in basin subareas for five commodity groups representing the bulk of today's waterborne commerce. Projections for transport on potential new waterways are from recent detailed studies.	A framework plan for further development of navigation resources is defined. Relating the urgency of need for the various plan elements to the evaluation years, results in a framework development program. Improvements needed to 2020, beyond those in the 1965 program, would cost about $1.81 billion. Framework program investment costs to 1980 would be $486,000,000.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Ohio River navigation	Gaum, C.H. History and Future of Ohio River Navigation. ASCE Proceedings, vol.96, Journal of the Waterways and Harbors Division, No.WW2, p.483-495, May 1970; Paper 7304.	The 981-mile long Ohio River Waterway has been continuously improved since it was first used to float cargo downstream. Introduction of steam vessels of the 1800's and development of highly efficient diesel tow boats have increased tow sizes and made modification of the earlier locks and dams mandatory. The old locks and dams being replaced and the new ones under construction are described. Continuing improvement in equipment and projected increase in traffic (estimated to be about 5 times the 1966 total of 25 billion ton-miles by 2020) will require continuous reappraisal and timely improvement to assure the maximization of economic returns from this already highly efficient system. The new locks and dams are efficiently designed and together with increased depth of the waterway should be able to accommodate the future traffic. However additional effort will be required to reduce delays and speed traffic as growth continues.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Selection of Parameters and Determinations of Method for Assessing the Transport Capacity of the Ohio River Waterway.	Gaum, Carl H., PIANC Bulletin, vol. 1, 1970, p.41.	Briefly discusses development of river tow transportation and freight traffic mode distribution in U.S. Outlines waterway capability parameters: Location; geometry- grade, depth, width, alignment, locks; obstructions; shore development; climatological factors- ice, storms, fog, floods, streamflow; darkness; structural improvements- locking times; dredging, accidents; traffic directionality, barge loaded time; fleet characteristics; and type of cargo. Discusses statistical studies for model development.	Concludes that locks are often critical factors in controlling waterway capacity. Waterway model should recognize profit motive of tow operators.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Tonnage capacity of canalized waterways	Bottoms, E.E. Practical Tonnage Capacity of Canalized Waterways. ASCE Proceedings, vol.92, Journal of the Waterways and Harbors Division, No.WW1, p.33-46, Feb. 1966; Paper 4644. Also appears with discussions in PIANC Bulletin, vol.3/4, no.25/26, p.3-52, 1967.	Paper develops the relationship between the practical tonnage capacity of a waterway and its maximum tonnage capacity. The relationship is found to be an approximate ratio of 1 to 4, that is, the PTC of a waterway is approximately 25% of its MTC. The maximum tonnage capacity is computable for all waterways. This tonnage is described as the optimum amount that can pass a lock in 365 days if each time the lock is operated, regardless of direction, its useable chamber dimensions are completely occupied by a tow with its barges loaded to the maximum draft permitted by the waterway, each lockage is performed in the minimum possible time, and the operation continues for 24 hr each day. Waterways with restrictions such as narrow channels requiring passing places were found to have relatively lower practical tonnage capacity than the waterways developed on the Illinois and Ohio Rivers.	The findings are suitable for application to studies of new waterways or the improvement of existing ones.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Analysis of waterway capacity	Shultz, R.P. Graphic Analysis of Waterway Capacity. ASCE Proceedings, vol.93, Journal of the Waterways and Harbors Division, No.WW4, p.177-184, Nov. 1967; Paper 5602.	Critical analysis of the capability of a proposed canalized waterway to economically move the tonnage of anticipated commerce is necessary, particularly in those instances where channel dimensions are limited and lock sitings are less than ideal. Plotting of probable vessel movements through the entire waterway, or critical reaches, by graphical means is a valuable tool in measuring waterway capacity. Essentially, the graphic method permits analysis of vessel movements by showing the position on the waterways of all vessels at any one time, and the trace of these movements show graphically interferences to movements and resultant delays for each and all vessels.	Physical elements of a waterway may be evaluated in reference to the capability of each to perform in balance with the others. The total practical tonnage capacity of the waterway may be determined, and time of transit for vessels may be more accurately estimated to determine the cost of moving commodities through the waterway.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Transport capacity of navigable waterways	Nishida, S., and others. Analysis of Shipping Traffic Capacity of Narrow Waterways on the Uraga Channel. Report to the XXIInd International Navigation Congress, Paris, 1969, Section 1, Subject 4, p.77-96.	One part of the paper on Japanese navigation practices concerns computation of shipping traffic capacity at Tokyo Bay entrance, by simulation.	Main flow chart of the simulation model of navigation is illustrated.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Transport capacity of navigable waterways	Rousselin, M. Report to the XXIInd International Navigation Congress, Paris, 1969, Section 1, Subject 4, p.35-52. (Paper in French with English summary).	After describing "classical method" of determining the maximum, theoretical and practical capacities of a waterway, as well as the optimum economic capacity, author presents a new "simulater method." (sic)	Computer is used to simulate traffic and give accurate information on the operation of the locks and the fleet of hypothetical traffic.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Systems Analysis of Waterways.	Implications of Systems Analysis to Inland Navigation DuWayne A. Koch, preprint to ASCE National Meeting on Transportation Engineering, Boston, Mass. July 70.	Notes continual increase in GNP and in crowding of waterway facilities. Limited reach analysis is no longer adequate and it must be recognized that the waterways system is only a subsystem of the total transportation system. Cites usefulness of simulation analysis but cautions that the model must be able to accurately project time effects. Identifies three principle elements of the waterway system as: The waterway characteristics; the towboat industry; and the waterborne commerce itself.	Rather general, makes good point concerning time projection model requirement.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Canal Capacity	The Welland Canal Capacity Problem, A. M. Luce and H. V. Fullerton. Report to Ottawa Section, Canadian Operations Research Society, April 28, 1966.	Discusses measures studied and taken to increase Welland Canal capacity. Measures discussed include: removal of bridge obstructions at locks; construction of stilling basins to reduce turbulence from lock inlet and discharge flows; longer approach walls; larger valves and plumbing; widening of canals; use of radar at bridges to aid bad weather navigation; traffic control techniques; and simulation studies. Also describes briefly the characteristics of the waterway system and some of the floating craft.	Repeats many of the items discussed in the previous Welland Canal study (Luce and Sandor, N-F-37).

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Improving Efficiency of Waterways	"Improvements in Lock Operations and/or Procedures to Increase Tonnage Passed Through Locks." (Author unknown, not dated) Attached to Memoranda fro[illegible] John P. Davis, ENGCW-[illegible] to Asst. Chief, Eng. Di[illegible], OCE, 28 Jan 70	Suggests many nonstructural improvements designed to increase waterway efficiency. Discussions cover: Limiting tow size; limiting multiple lockages; requiring adequate towboat power and tow manuevering devices; encouraging maximum user help and cooperation; improving lock approach channels; providing longer guide walls, mooring cells, and fleeting areas; adopting standard lock operating procedures and revising tow lockage criteria; providing tugboats and/or travelling kevels; improving communications between personnel at locks; and maintaining more open river. Says precise lockage scheduling impractical but target times might be helpful. Special handling for pleasure craft should be adopted.	Good discussion of operational and minor construction changes for increasing lock capacity.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Systems approach to Canal capacity	A Systems Approach to the Problem of Increasing the Effective Capacity of the Welland Canal. Luce, A. M. (The St. Lawrence Seaway Authority) & Peter Sandor (J. Kates & Assoc.) 1965, Report prepared for The Canadian Transportation Research Forum.	Part I (Luce) General description of the Welland canal and related reaches of the Seaway. Describes physical waterway, floating stock, and commodities.	Good background information to part II.
		Part II (Sandor) Notes that mechanistic indicators cannot replace sound management or nonfinancial considerations such as safety. It was found that queue problem was one of random arrivals rather than of maximum capacity. Also found that operation halts greatly increased queue problem and that periods of no demand were wasted. Problems usually resulted from single slow lock and measures taken included: Priority feeding of slow lock; locking scheduling considering vessel characteristics and optimized tandem locking; greater vessel storage to permit continued locking durring bad weather; use of special control board. Communications with shipping industry found greatly improved by hiring retired ship captain as liaison.	Provides excellent examples of successful nonstructural capacity increases.

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ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Economic Impact of Waterways	"Broad Scope of Navigation's Economic Impact," Foster, M. I., Journal of the Waterways and Harbors Division, ASCE, Vol. 95, No. WW1, Proc. Paper 6389, Feb. 69, pp. 23-34.	Recognizes sharp competition for public funds and need for accurately assessing project benefits. Discusses impact of waterways on economic growth of an area with particular consideration of the Tennessee River waterway. Summarizes considerable data on commodity production employment and presents a case study of industry interactions in the Decatur Ala. area.	Good discussion related to waterway-commodities interactions.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Economic justification of inland waterway improvement	Bottoms, E., and Li, S.T. Report to the XXth International Navigation Congress, Baltimore, 1961, Section 1, Subject 1, p.207-222.	Presents authors' views on current methods and workable criteria which may be adopted for guidance in determining the economic justification of inland waterway improvements in both developed and underdeveloped countries.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Waterways, General	Barge Transportation--Energizer of Production and Marketing, Carr, B. B. (AWO), Journal of the Waterways and Harbors Division, ASCE, Vol. 95, No. WW2, Proc. Paper 6559, May 69, pp. 163-173.	Towing industry affects movement of commodities into new markets as well as providing low cost transportation. Article cites numerous improvements in barge and towboat technology and in the physical waterways. Notes development of new terminals and cargo handling methods. Gives many statistics related to waterway transportation and predicts great increases in transportation needs. Points out waterway effects on new markets and the far reaching benefits of the waterways. Suggests more intermodal transportation coordination to meet future needs.	Very good general description of barge transportation. Slightly inclined to favor waterways transportation viewpoint.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Double circuit for water movements to prevent salt water intrusion at locks	Beau, F., and D'Avaucourt, De Vitry. Report to the XXIst International Navigation Congress, Stockholm, 1965, Section 1, Subject 1, p.61-78. (Paper in French with English summary).	Paper gives details of the Jeu de Mail locks linking the Bourbourg Canal with the Dunkirk port basins and also of tests performed on a scale model for study of the Mardyck lock project at the entrance to the new Dunkirk-Valenciennes link. The device to prevent the penetration of salt water in the Jeu de Mail locks is made up of an intermediate pool the level of which is controlled at a line lower than the adjacent water levels. The Mardyck lock project studied on a scale model comprises a double circuit for water movements - one for soft water and the other for salt water; it demands the services of a high-capacity pumping-station. Tests performed on the model have brought to light its very high efficacity against the intrusion of salt. Paper also gives some data on model study of soft water diffusion in sea water.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Control of Aquatic Plants	Jernigan, O.M., and others. Control of Obnoxious Aquatic Plants in the Southeast. ASCE Proceedings, vol.91, Journal of the Waterways and Harbors Division, No.WW4, p.31-46, Nov. 1965; Paper 4536.	Obnoxious aquatic plants have caused problems in waters of the southeastern states since approximately 1900. Federal, state, and local agencies are engaged in an extensive cooperative effort for control of these plants for the benefit of navigation, drainage, flood control, fish and wild life conservation, public health, and related activities.	Chemicals are being used in recent years in lieu of earlier use of mechanical equipment for destruction of the aquatic weeds. The most common chemical now in use is 2,4-D; however, continued research is being conducted in search of more effective and more economical means.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Control of Aquatic Plants	Guscio, F.J., and others. Water Resources Problems Generated by Obnoxious Plants. ASCE Proceedings, vol.91, Journal of the Waterways and Harbors Division, No.WW4, p.47-60, Nov. 1965; Paper 4537.	Infestations of obnoxious aquatic plant growths distributed throughout United States create costly problems in beneficial uses of the water resources. Programs for control and possible eradication of the most objectionable species are underway. Plant growths causing difficult problems in the humid regions are of the emersed and floating types, with some submersed plants. In the arid regions, objectionable plants include the submersed type, the phreatophytes, and ditchbank vegetation. Aquatic plants are seriously affecting navigation, flood control, agriculture, irrigation, drainage, recreation, fish and wildlife, public health, water supply, and water pollution control. The presence, persistence, and succession of aquatic weeds require engineers and scientists to modify design considerations and to continue research for economical control of objectionable aquatic vegetation.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Weed control by laser	CE Studies Use of Laser to Control Weeds in Water. Army Research and Development, vol.10, no.4, p.1, 6-7, April 1969.	The concept of using specially designed lasers to cope with the problem of aquatic weeds was developed by Dr. R. A. Scott, Jr., Chief of the Corps' Aquatic Plant Control Program. Technical details have been made to the U.S. Patent Office. Use of chemicals and insects to control weeds in waterways also is being studied.	Preliminary tests have demonstrated feasibility of the concept of laser control, using the powerful laser in the Physical Sciences Laboratory at Redstone Arsenal. Research is continuing to determine the most effective level of exposure.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Weed control machine	Webster, L.F. New Machine Makes Weed Control Effective. Water and Pollution Control, vol.105, no.7, p.24-25, July 1967.	Newly-developed machine designed for weed control, particularly on navigable channels; equipment, called Aquatic Harvester, and its accompanying tender are combination of land-and-water mobile vehicle; harvester is flat-bottomed barge on which has been mounted hydraulically-operated equipment for cutting reclaiming weeds, twin paddle wheels by which it is propelled and steered, and storage basket in which cut weed is stored until transferred at intervals to tender.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Retractable fender system	Picco, J.F., and Blancato, V. Resilient Ferry Slip with Retractable Fender System. ASCE Proceedings, vol.94, Journal of the Waterways and Harbors Division, No.WW3, p.297-303, Aug. 1968; Paper 6062.	The design of a ferry slip using retractable contact frames, moving inward and upward on bearing brackets with tracks of various inclination is described. Rigid frame on which the brackets are fastened is explained in detail and its stability analyzed. The movable frames with rotating contact cylinders are described and evaluated. The kinetic energy transmitted to the slip by a 3,000-ton ferry approaching with a speed of 3 fps is calculated. The energy absorption capacity of the various frames of the slip under different acting force is determined.	The various advantages, functional and economical, of this new design of a ferry slip with retractable fender, over the ferry slip, are enumerated.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Inland Navigation	"Evolution of Propulsion and Control of Cargo Vessels on the Inland Waterways of the United States," Person, John L. and Robert E. Mytinger, PIANC 19th International Navigation Congress, London, Section 1, Question 2, 1957, pp. 59-80.	Traces development of waterborne transportation on the Mississippi River system from muscle power to steam power to diesel power. Describes equipment of modern, highly manueverable diesel towboats: Twin screw design, rudder system, Kort nozzles, hull design, and such electronic devices as radio, radar, and rate of swing indicators. Discusses reasons for economic superiority of towboat/barge fleets over self propelled vessels.	Contains essential information in regard to towboat development to 1957.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Inland Navigation	"Measures to be Taken to Ensure Uninterrupted Day and Night Navigation Under all Weather Conditions," Ingersoll, A. C. Jr. and Donald L. Steele, PIANC 20th International Navigation Congress, Baltimore, Section 1, Subject 3, 1961, pp. 153-165.	Discusses many aspects of barge tow navigation on the Mississippi River system and various navigational aids in use. Describes standard diesel towboat and common barge types. Defines navigational problems related to: Currents, tow size, locks and dams, bridges, making landings, wind, bad weather, and river bends. Discusses usefulness of electronic devices such an radar, sonar, and automatic pilots but notes that such devices have limitations and that night and bad weather navigation is still troublesome.	Article does not represent latest information on navigational aids but many of the problems discussed are still important.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Uninterrupted day and night navigation under all weather conditions.	Dahme, Hans. Report given at XXth International Navigation Congress, Baltimore, 1961, Section 1, Subject 3, p.5-36. (Report in French with English summary).	Describes navigation by day in these categories: a. By sight 1. Observance of fair-way channel 2. Standing instructions 3. Hints of collision avoidance b. On supervised waterways c. By signals For night navigation the following media are described; a. Optical b. Acoustic c. Radio	Warns against dazzling by lights; recommends loudspeakers as complement to optical media where there are bottlenecks (locks). Clue to costs per kilometre is given (for German waterways).

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Uninterrupted day and night navigation under all weather conditions	De Rudder, Paul, and Lievens, Raoul. Report given at XXth International Navigation Congress, Baltimore, 1961, Section 1, Subject 3, p.37-57. (Report in French with English Summary).	Paper is restricted to study of measures to be taken to permit navigation by night and in foggy weather in the case of inland navigable waterways which have water level widths of between 25 and 75m.	It is proposed that the average speeds of navigation by night be fixed; care must be taken to avoid dazzling; general lighting of waterway meets with great difficulties; radar needed for night fogs (radar experiments were carried out on the Albert Canal); authors conclude that navigation by night and by radar is possible on waterways of limited width when simple safety measures are applied.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Push towing	Horton, C.R. Push Towing Technology in the United States. Report to the XXth International Navigation Congress, Baltimore, 1961, Section 1, Subject 4, p.229-254.	Paper discusses history of push towing, equipment, choice of propulsion method, barge selection, model testing experience, and barge resistance. Includes diagrams of towboats and charts on towing efficiency.	Paper gives the current situation in the U.S. in relation to the major features of towboat propulsion and presents recent data on equipment. Author states that complete subject of push towing technology cannot be covered in article of this length.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Push towing	Soyuzov, A.A., and Rizhov, L.V. Push Towing of Vessels on the Inland Waterways of the U.S.S.R. Report to the XXth International Navigation Congress, Baltimore, 1961, Section 1, Subject 4, p.255-272.	Push towing in the Soviet Union has begun to develop rapidly since 1952. This article is a general summary of a decade of push-towing, gives description of the craft, and has one section on navigation.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Determination of density of shipping traffic by means of an acoustical counter	Boshuizen, P.C., and others. Report to the XXIInd International Navigation Congress, Paris, 1969, Section 1, Subject 2, p.49-58.	Traffic along the Netherlands waterways is counted at various spots (e.g., at locks or bridges on canals), but there is demand for more knowledge about the density of shipping traffic on rivers.	An acoustical device to count the number of ships passing a checkpoint has been developed and is described in this paper.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Electronic devices on towboats	Foster, M.I., and Nichols, R.B. Electronics in the Operation of Waterways and River Fleets. Report to the XXIInd International Navigation Congress, Paris, 1969, Section 1, Subject 2, p.59-73.	One section of this paper is concerned specifically with electronic devices on towboats. Describes echo sounders (particularly useful on the Mississippi River), rate-of-swing indicators, and auto-pilot systems.	Use of this equipment under appropriate conditions have resulted in substantial fuel savings and in safety.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Single channel radio-telephone	The Navigator's Single Channel Radiotelephone, Effective Aid to Maritime Safety. PIANC Bulletin, vol.4, no.6, p.49-53, 1962.	Study was made of circumstances surrounding collisions in the Delaware River and Bay area; need for radiotelephone communication between navigators was obvious.	Single-channel radio meets the requirement of reliability plus simplicity. FCC approved the program and assigned frequency 156.65 Mc for navigational purposes only (available to all commercial vessels, all government vessels, other craft showing need, and to bridge and lock control stations). General Electric Co. has perfected a new self-contained radio-telephone weighing only 52 oz., with rechargeable batteries, in a high-impact plastic case, about the size of a Polaroid camera.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Composite craft	Grafton, O.H., and Blenkharn, Allen. Report to the XXIInd International Navigation Congress, Paris, 1969, Section 1, Subject 1, p.253-268.	One part of this report concerns the problem of shipping coal in Great Britain by means of composite craft.	The craft designed is capable of using the inland waterways for parts of its journey but can be assembled and integrated into a much larger craft for a sea voyage. This allows loading coal near its source. This craft has been model tested and is ready for sea trials.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Coupling pushing units	Wurmböck, H.G. Shortening the Duration of Round-trip Journeys of Ship Formations on Long and Nautically Different Waterways by Means of Coupling Pushing Units. Report to the XXIInd International Navigation Congress, Paris, 1969, Section 1, Subject 1, p.53-68.	Automotive coupled unit is made up by 2 motor cargo ships each having 870 h.p. and a maximum carrying capacity of 970 tons as well as of 4 pushed barges with a carrying capacity of approximately 940 tons each.	In comparison the automotive coupled unit is favored over the traditional pushing unit. The former is 34% faster and has better manoeuvrability. Since the automotive coupled unit has two self-propelled motor cargo ships, convoy could be divided into two parts (each having a self-propelled ship and two lighters). Author claims the economic efficiency of the automotive coupled unit is three times as high as that of the traditional towing unit and 70% higher than that of the pushing unit.

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ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Towboats	"NABRICO Launches 'M/V John S Herbert' to Work Cumberland and Tennessee Rivers." Pit and Quarry v. 59, Dec 66 p. 90.	Describes 2295 HP towboat received by W.G. Bush Co. Boat is 105' x 34' x 10'. Powered by 3 Cat D398's has 3 steering and 6 flanking rudders.	General description of late model type towboat.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Barge tow performance	Howe, C.W. Mathematical Model of Barge Tow Performance. ASCE Proceedings, vol.93, Journal of the Waterways and Harbors Division, No.WW4, p.153-166, Nov. 1967; Paper 5588.	A mathematical model for predicting tow operating speeds is derived from test data and engineering principles. Land speed is expressed as a function of flotilla length, breadth, and draft, towboat horsepower, channel width, depth, and river current. The resistance function used is compared with those used by Langbein and Rouse. The speed predictions of the model are compared with actual average speeds of tows operating on the Ohio, Illinois, and Mississippi Rivers under a variety of operating conditions.	The model proves a statistically significant representaion of tow performance when adjusted by data from the area for which predictions are to be made.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Barge Tow Performance	"On Acceleration of Barge Tows," DeSalvo, Joseph S., Journal of Waterways and Harbors Division, ASCE, Vol. 95, No. WW2, Proc. Paper 6545, May 1969, pp. 121-129.	Develops barge tow acceleration model based on Howe's resistance and effective-push functions.	May find application in tow performance simulation.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Barge Tow Performance	"On Acceleration of Barge Tows," Discussion by DeSalvo, Joseph S. and John S. McNown, Journal of Waterways and Harbors Division, ASCE, Vol. 96, No. WW2, Proc. Paper 7252, May 70, pp. 553-557.	Discussion suggests model deficiencies and possible corrections.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Handling of push-barges detached from the tow	Kleinjan, I.L., and others. Report to the XXth International Navigation Congress, Baltimore, 1961, Section 1, Subject 4, p.195-227.	Brief section in this paper on push-towing concerns practice in Rotterdam of handling push-barges detached from the tow.	Transport of separate barges has been carried out with help of ordinary tugboats. A barge measuring about 70 x 9.5m is as a rule propelled by two tugboats alongside the barges.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Barge decks	Helbock, W.P. Barge Decks Resurfaced with Asphalt. Civil Engineering, vol.35, no.11, p.54-55, Nov. 1965.	Economical method of repairing decks of wood and steel barges, damaged by unloading buckets, by paving with asphalt is described; tight, fine asphalt is used as wearing surface over binder course; for first installations, old rail was welded to deck to prevent gouging; as mixes have been improved rail has become less necessary.	Use of asbestos fiber in mix showed good results. Suggested specification and detailed mix are given.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Barges	"Self-Unloading Barge Reduces Transportation Costs in Handling Sand, Other Cargoes" Pit and Quarry v. 59, June 67 p. 125-6.	Deeks-McBride Ltd. of Vanc. B.C. uses 4500 ton self unloading barge. Barge is 225' long with cargo area approx. 200' x 50' x 20'. Five yard drag scraper scoops material out of hold and dumps it on shuttle conveyor system for delivery to shore conveyor.	Describes one type of efficient barge unloading concept.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Barges	"Fleet of 34 Self-Unloading Barges of 7500-bbl Capacity Delivers Cement to Six Terminals Ranging from Minneapolis to Nashville and Houston" Pit and Quarry v. 61, July 68 p. 98.	Dundee Cement Company now operating fleet of 34 Dravo built barges. Fleet cost $4 million, barges are covered and measure 195' x 35' x 12'. Towing contract is with Southern Transfer Company. Each unloading terminal has "floating dock" unloader which uses vacuum/pressure technique to unload barges in 8-10 hrs. at 200 to 250 tons per hour. One terminal situated within Clarksville Wildlife Refuge.	Describes type of efficient barge unloading operation.

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Mooring ropes	Wilson, B.W. Elastic Characteristics of Moorings. ASCE Proceedings, vol.93, Journal of the Waterways and Harbors Division, No.WW4, p.27-56, Nov. 1967; Paper 5565.	Weight, strength, and elastic properties of steel-wire and fiber mooring ropes are examined for purposes of predicting their elastic behavior under dynamic conditions. Most of the essential properties can be generalized by empirical formulas that apply to all ropes when the appropriate values of certain constants are known. Effect of the elastic properties of mooring ropes in generating restraint-motion functions, governing the behavior of a moored object, are discussed with reference to anchor-line mooring and to normal harbor mooring. The fatigue properties of mooring ropes, inferred by analogy from the known fatigue properties of steels, are also examined.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Model to forecast traffic volume	Silberberg, E. The Demand for Inland Waterway Transportation. Water Resources Research, vol.2, no.1, p.13-29, 1966.	A new type of forecasting model of great potential for predicting flows in complicated spatial transportation networks is illustrated through application to the forecasting of interregional coal flows by barge over the Mississippi River system. Changes in these flows are related to regional coal production and consumption levels and to the freight charges by barge and rail. The special feature of the model is the great saving on the data needed for its implementation made possible by assuming that transportation patterns will be efficient, i.e., least-cost, for given regional imports and exports. This assumption is incorporated by using the linear programming transportation method to generate individual flows from regional barge imports and exports forecasts by a system of statistically fitted equations. Various applications are illustrated.	

ITEM	DESCRIPTION (REFERENCE CITATION)	DISCUSSION	CONCLUSIONS AND/OR EVALUATION
Railways	"The Future of Railways in the Transportation System." Bentham, J. M., Engineering Journal, Vol 52, No. 3, March 69, pp. 7-11.	Discusses modal transportation split, anticipated railway growth, unit trains, automatic electronic control devices, track and rolling stock improvements. (Canadian publication)	Cites advances from use of electronic devices.

APPENDIX G: SELECTED BIBLIOGRAPHY

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13. ABSTRACT

The inland waterways system of the United States as its exists today has a number of problems associated with near-capacity traffic conditions. In many places on the Mississippi, Ohio, and Missouri Rivers and their navigable tributaries, there are serious impediments to the free flow of waterborne commerce. This study was conducted to determine the potential for more efficient utilization of existing inland waterways resources and facilities as a possible alternative to heavy investment in major construction. The study was based on distribution of a questionnaire, meetings and discussions with the Civil Works Task Group for Inland Waterways Systems Analysis, and visits to Corps of Engineers Civil Works offices and river sites by the author. The inland waterways system is an intimate interweaving of three significant subsystems: the physical waterway, the towing industry, and commodities. These subsystems and their interrelations are discussed in detail herein. It was determined that there are a number of areas of potential for improvement in the inland waterways system. These areas involve such items as changes in operating procedures of the locks, revisions of the operating rules for towboats approaching and using locks, staffing considerations, additional assistance at heavily trafficked locks, and other such factors. The following two examples illustrate possible improvements. The study of the Welland Canal in the Canadian portion of the St. Lawrence Seaway was a most productive effort. Through improved management of both the lock system and the shipping in the canal, major investments were delayed while significant increases in ship passage were realized. Also, at the industrial canal in New Orleans, Louisiana, and in recent tests at Lock and Dam 26 on the Mississippi River near St. Louis, Missouri, the use of extra towboats to assist long tows through the locks was very productive. In the Lock and Dam 26 tests, an estimated $100,000 in time-saving benefits was realized by the towing industry for a $26,000 cost. It is concluded that there is considerable evidence that significantly more traffic can be passed through our inland waterways system through the medium of nonstructural or low cost modifications in operating rules, lock operations, and facilities. This will enable the Civil Works Directorate to apply capital improvement investment more effectively at the places where it is the only solution while materially increasing our capability to pass increased traffic at other locations for considerable periods of time. It is recommended that the Office, Chief of Engineers, actively pursue the concept of nonstructural or low cost improvements in lieu of major construction prior to major investments at any given location. The effect of any improvements should be evaluated with regard to that location and also with regard to other locations under the systems concept.

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